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INSTITUTE OF THE AERONAUTICAL SCIENCES

AERO/SPACE ENGINEERING

REVIEW OF CURRENT AND FUTURE TRENDS IN AIRCRAFT • MISSILES • ROCKETS • SATELLITES • SPACECRAFT

Manned Nuclear Space Systems

Part I—High-Thrust Nuclear Systems . . . p. 34

EDITORIAL: *What Price Originality?* . . . p. 31

JANUARY/1960

FROM LAGRANGIAN TO LIFT-OFF

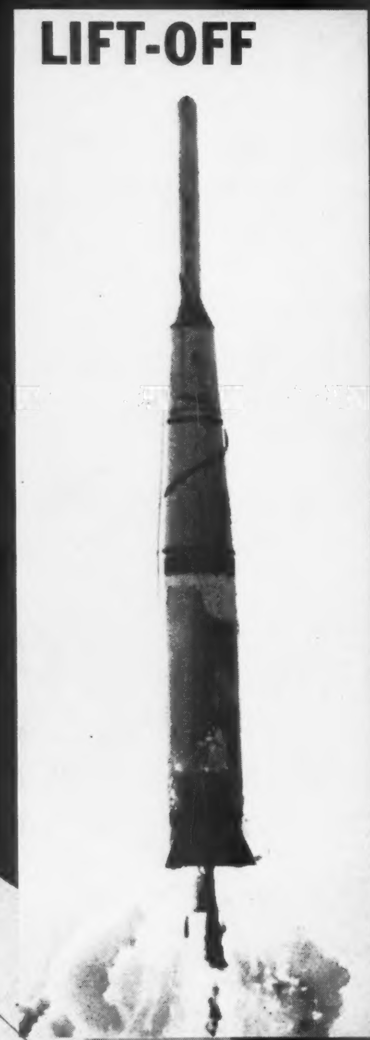
Sometimes forgotten during the thundering ascent of a space probe rocket are months of meticulous analysis, engineering and planning. The staff of Space Technology Laboratories is now engaged in a broad program of space research for the Air Force, the National Aeronautics and Space Administration and the Advanced Research Projects Agency under the direction of the Air Force Ballistic Missile Division. For space probe projects STL provides the total concept approach, including preliminary analysis, sub-system development, design, fabrication, testing, launch operations and data evaluation. The total task requires subtle original analysis in many fields as well as sound technical management.

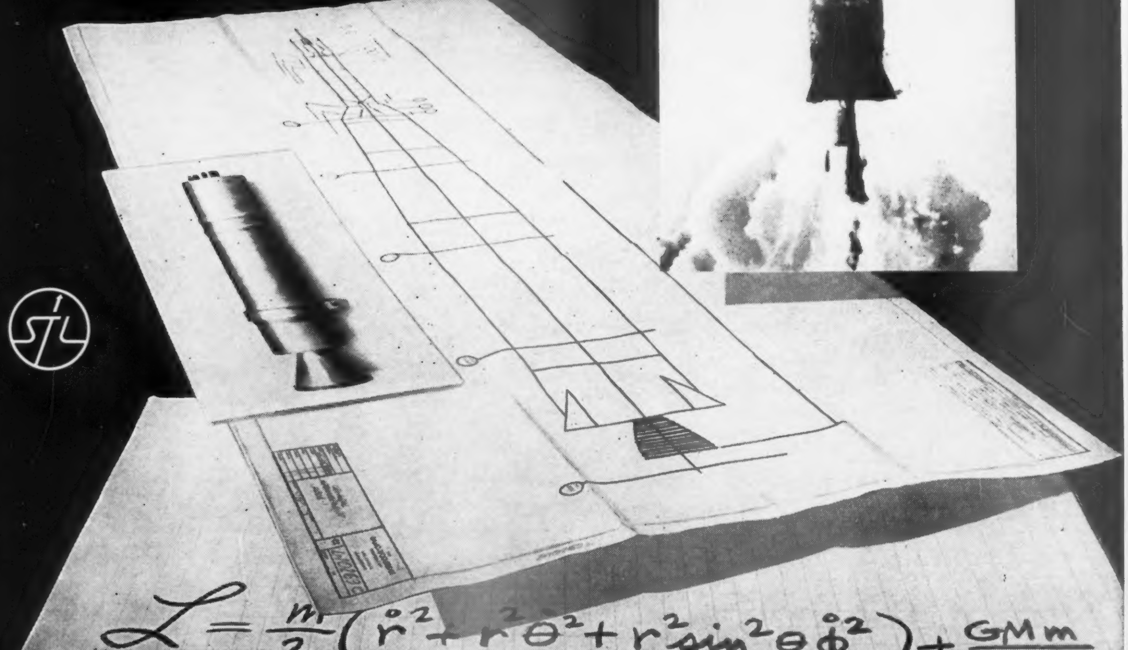
The STL technical staff brings to this space research the talents which have provided system engineering and technical direction since 1954 to the Air Force Ballistic Missile Program. Major missile systems currently in this program are Atlas, Titan, Thor and Minuteman.

The scope of STL's responsibilities offers creative engineers, physicists and mathematicians unusual opportunities to see their ideas tested in working hardware. Inquiries are invited regarding staff openings in the areas of Advanced Systems Analysis, Rocket Propulsion, Space Flight Mechanics, Dynamics, Structural Analysis, and Aerodynamics.

Space Technology Laboratories, Inc.

P. O. Box 95004, Los Angeles 45, California





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"The prestige magazine of the Aerospace Industry"

AERO/SPACE ENGINEERING

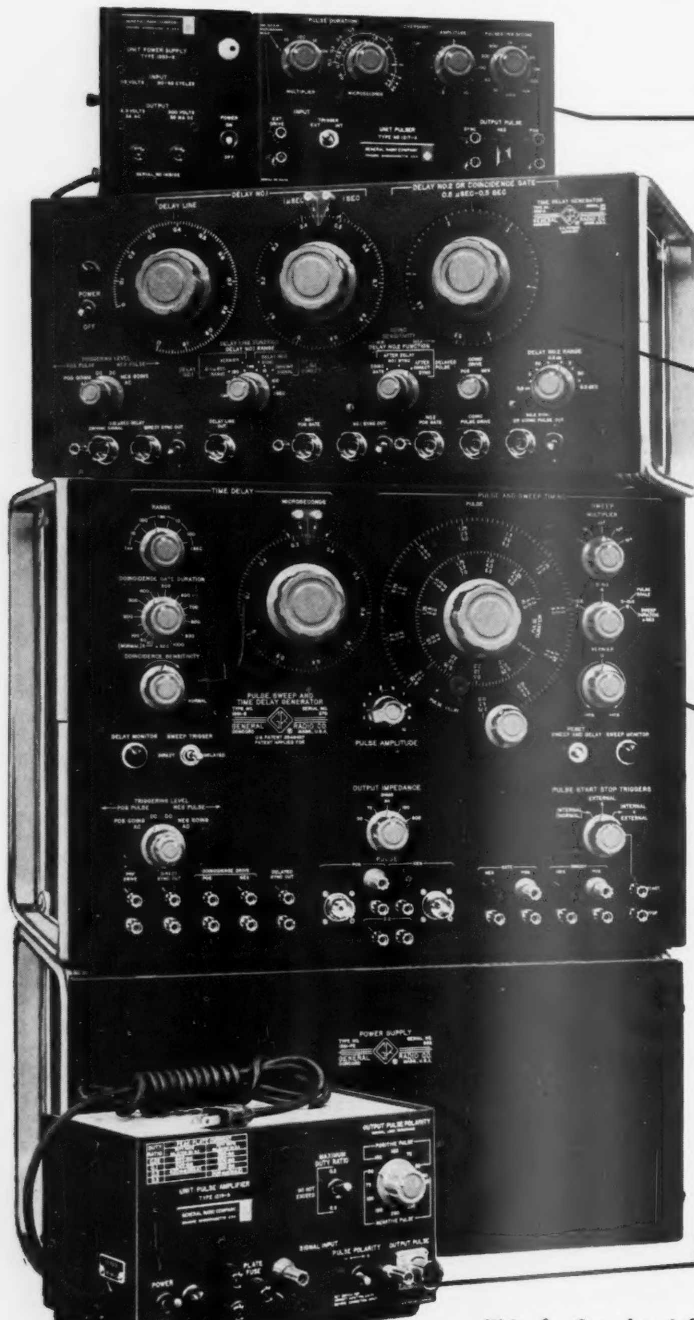
VOLUME 19 / NUMBER 1 January 1960

Featured in this issue

Departments

INSTITUTE OF THE AERONAUTICAL SCIENCES

For Those Working With Pulses...



Type 1217-A UNIT PULSER . . . $235
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Repetition Rate: 30c, 60c; 100c to 100 kc in 1-2-5 sequence. 15c to 100 kc continuous with external drive.
Pulse Duration: 0.2 to 60,000 μsec, continuously adjustable.
Rise Time: 0.05 μsec **Decay Time:** 0.15 μsec

Type 1392-A TIME-DELAY GENERATOR . . . $985

The most precise and flexible delay generator available. Two independent delay circuits (0 to 1.1 sec and 0.5 μsec to 0.5 sec) can be "series connected" for 0 to 1.6 sec range in delay. Coincidence circuitry makes possible exact delays and pulse bursts. Input circuits accept almost any waveform from dc to over 300 kc to initiate action. Built-in provision for time modulation.

Type 1391-B PULSE, SWEEP, AND TIME-DELAY GENERATOR . . . $1975

Complete, accurate, wide-range time measurements and pulse-waveform synthesis with one instrument. Fast rise and decay times — better than 0.015 μsec. No duty ratio restrictions.

Pulse Duration: 25 mμsec to 1.1 sec
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Delay Repetition Rate: 0 to 400 kc

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Letters

More on Reliability

■ The letter to the Editor in the August issue of AERO/SPACE ENGINEERING by Dr. Alfred M. Freudenthal, MIAS, warrants comment on several counts.

The initial letter by IAS President William Littlewood, January, 1959, and subsequent responses by this writer and others on reliability were stimulated by a situation which, if not new as Dr. Freudenthal challenges, is deserving of special attention by the aeronautical engineering profession. Perhaps from the beginning of the aerospace era, emphasis in technical developments has gone to the discovery of ways to advance performance. Making good on these advances in terms of dependability, durability, etc., in the theater of operations has not been a concern of many in the aeronautical engineering profession. (President Littlewood is a distinguished member of the minority which has spoken out in favor of greater attention to the operating problems.)

In this characteristic the field of aeronautics has been uniquely different from civil engineering in which Dr. Freudenthal is no doubt most knowledgeable. Limited attention to the problems of mission accomplishments in aviation in contrast to the great emphasis on speed, altitude, and range has resulted in a like disproportion between the ability to predict longevity in operations in comparison with the ability to predict performance. A classical formulation in aeronautics is the Breguet range equation. This equation says nothing about durability. This is the nub of our problem. I don't wonder that aeronautical people sound "off the rocker" to the good professor. It would be inconceivable to him to have one of his civil engineering students design a bridge or water main with anything less than permanent durability. In aeronautics, criteria for durability are still in a primitive state, and the topic of reliability fares no better.

In regard to my comments on failure statistics, I wish to restate with greater emphasis that statistics can play an important part in dealing with reliability. On the other hand, the key to solving the aeronautical reliability problem is in gaining an understanding of the mechanisms of malfunction. Statistical tools are an aid to identifying the major problem areas and their gross characteristics. These data will be an important step toward understanding failure mechanisms. Finally, I wish to refer Dr. Freudenthal to

(1) NACA Research Memo E55HO2, *Factors That Affect Operational Reliability of Turbojet Engines*, Jan. 31, 1956,

(*Continued on page 106*)

The Editors welcome letters from readers, although none can be acknowledged. All must be signed, but identities will be withheld on request.

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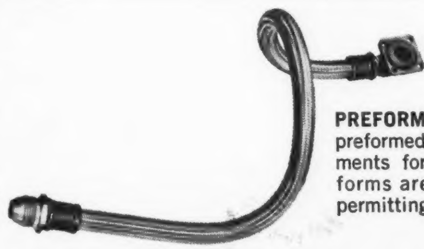

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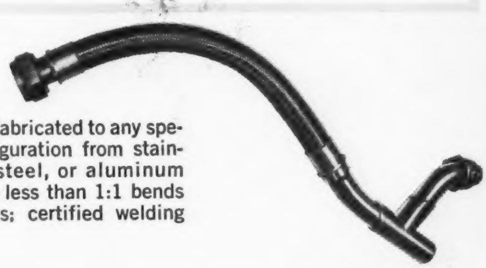

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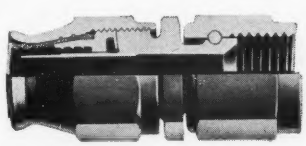

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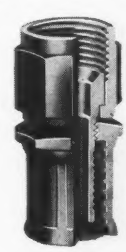

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Typical of the results are electrically suspended navigation gyros, adaptive flight control systems, and guidance and control for space vehicles. Sergeant, Thor, Atlas, Titan, Polaris, F-104, B-58, WS 117L, Scout, Mercury . . . Honeywell equipment is on all of these and many more.

Current expansion has created openings for senior and junior engineers and scientists in these and similar programs. Your inquiry will get prompt and confidential attention.

the Green Sheet

IAS BULLETINS AND LATE NEWS...

January 1960

ANNUAL MEETING LUNCHEON SPEAKER for Monday, January 25 will be Rear Admiral Paul D. Stroop, USN, Chief of the Bureau of Naval Weapons.

LT. GENERAL BERNARD A. SCHRIEVER, USAF, Commander, Air Research and Development Command, will be guest of honor and principal speaker at The Flight Propulsion Meeting dinner in Cleveland, Ohio, on March 10.

THE IAS FLIGHT TEST FELLOWSHIP is again being offered to U.S. citizens who will have received a Bachelor's degree by June 1960. This annual award, for two years of advanced study at Princeton University, offers tuition and stipend totalling $7,800. Applications may be obtained by a request in writing, endorsed by a sponsoring reference (e.g. faculty member or employer), addressed to Flight Test, IAS, 2 East 64th Street, New York 21, N.Y. Closing date for application is March 1, 1960.

ALL SEVEN IAS REGIONAL STUDENT CONFERENCES have been set as follows: West Coast—March 31-April 1, Los Angeles, Calif.; Northeastern—April 9, Polytechnic Institute of Brooklyn, Brooklyn, N.Y.; St. Louis—April 22, St. Louis, Mo.; Southwestern—April 28-30, Dallas, Texas; Middle Atlantic—April 29-30, West Virginia Univ., Morgantown, West Va.; Southeastern—May 5-6, Atlanta, Ga.; Detroit—May 9, Wayne State Univ., Detroit, Mich.

APPLICATIONS ARE NOW BEING ACCEPTED FOR THE DANIEL AND FLORENCE GUGGENHEIM FELLOWSHIPS for 1960-61 graduate study at the Jet Propulsion Centers at California Institute of Technology and Princeton University, and the Institute of Flight Structures at Columbia University. For information and application forms write: The Daniel and Florence Guggenheim Foundation, 120 Broadway, New York 5, N.Y. Applications should be filed no later than March 1, 1960.

EDITOR'S NOTEBOOK: Of Special Interest to IAS members whose work takes them into the realm of electronics will be a series of five articles on an important area of the field to be published during the year in Aero/Space Engineering. To cover electronic equipment cooling, they are being prepared exclusively for this magazine's readers by Alvin R. Saltzman, MIAS, Bruno T. Plizak, Leonard F. Tomko, and James Nycum. All have been active in the U.S. Naval Air Development Center's continuing investigation of air, as well as simultaneous heat-and-mass-transfer methods of cooling, and authored "Regenerative Heat Sinks for Airborne Electronic Equipment," which appeared in last month's issue. Titles of articles in the series, brief summaries, and dates of appearance, will appear in the Green Sheet for February.

SECTION MEETINGS CALENDAR

Jan. 6	Philadelphia: Dinner Meeting, Penn Sherwood Hotel, 6:30 p.m., "Airborne Hunting for an Elusive Quarry in the Jungle of the Sea", by Rear Admiral J. N. Murphy, USN.
Jan. 12	Cleveland-Akron: Dinner Meeting and Tour, Engineering & Science Hall, Fenn College, "RAMP—The Raytheon Airborne Microwave Platform System" by Dr. Harry Letaw, Jr., Advanced Development Group, Raytheon Company.
Jan. 12	Los Angeles: Specialists Meeting, IAS Building, 8 p.m., "Bridging the Gap Between Injector Hydraulics and Combustion Phenomena in Liquid Propellant Rocket Engines" by Jack H. Rupe.
Jan. 12	Washington: Dinner Meeting, Occidental Restaurant, 6 p.m., ARDC Command Briefing, Col. Carlo R. Tosti, Asst. for Command Presentations, Hdqts. ARDC.
Jan. 13	Niagara Frontier: Dinner Meeting, Cornell Aeronautical Lab. Cafeteria/Auditorium, 6:45 p.m., "Man in Space."
Jan. 15	Great Salt Lake: Dinner Meeting, Officers' Club, Hill AFB, 6:30 p.m., "Your Navy and Your Future", by Darrell H. Zwemke, LCdr., USNR.
Jan. 15	Tulsa: Family Night Dinner, Borden's Sheridan Village, 6:30 p.m., Movies of General Interest Will Be Shown.
Jan. 19	Washington: Specialists Meeting, National Academy of Sciences Auditorium, 8 p.m., "Aircraft Reliability Starts with Preliminary Design" by John deS. Coutinho, Ch. of Reliability, Grumman Aircraft Engineering Corp.
Jan. 21	Los Angeles: Dinner Meeting, IAS Building, 6 p.m., "Smog in the Crystal Ball" by William Littlewood, V.P.-Equip.Res., American Airlines.
Jan. 26	Los Angeles: Specialists Meeting, IAS Building, 8 p.m., "Single Tube Heat Transfer Tests—Gaseous and Liquid Hydrogen" by H. Howard Walters.
Jan. 29	Los Angeles: Historical Meeting, IAS Building, 8 p.m., "Air Race Night", panel of early race pilots.

INTERNATIONAL, NATIONAL, AND JOINT MEETINGS CALENDAR

Jan. 25-27	28th Annual Meeting, Hotel Astor, Times Square, New York.
Mar. 10-11	Flight Propulsion Meeting (Classified), Cleveland, Ohio.
Apr. 20-22	Symposium on Manned Space Stations (cosponsored by NASA and The RAND Corp.), Ambassador Hotel, Los Angeles, Calif.
May 2-4	IRE Aeronautical Electronics Conference (Participation by Dayton Section of IAS), Dayton, Ohio.
May 23-25	National Telemetering Conference (cosponsored by IAS, ISA, AIEE and ARS), Hotel Miramar, Santa Monica, Calif.
May 25-27	Specialists Meeting, Guidance of Aerospace Vehicles, Boston, Mass.
June 27-Jul 1	Summer Meeting, Ambassador Hotel, Los Angeles, Calif.
Sept. 12-16	2nd International Congress, International Council of the Aeronautical Sciences, Zurich, Switzerland.
Oct. 3-5	Midwestern Conference on Air Logistics, Tulsa, Okla.
Oct. 17-18	CAI/IAS Joint Meeting, Queen Elizabeth Hotel, Montreal, Canada.
Oct. 20-21	Symposium on Hypervelocity Techniques, Denver, Colorado.
Dec. 17	Wright Brothers Lecture, Washington, D. C.

IAS *News*

. . . a record of people and events of interest to Institute Members

Lt. Gen. Donald L. Putt New IAS President

1960 Officers to Be Introduced at Honors Night Dinner

LIEUTENANT GEN. Donald L. Putt, USAF (Ret.), President of United Research Corporation of Menlo Park, and a Fellow of the Institute, has been elected President of the IAS for 1960. He succeeds William Littlewood, Vice-President—Equipment Research for American Airlines.

President-elect Putt and the other new officers will take office following the Annual Business Meeting on January 27. They will be introduced at the IAS Honors Night Dinner on Tuesday, January 26. Identities of others elected to Institute positions will appear in next month's AERO/SPACE ENGINEERING. (See also pp. 32, 33, this issue.)

General Putt—recipient of a number of decorations, including the Distinguished Service Medal, Legion of Merit with Oak Leaf Cluster, Bronze Star with Oak Leaf Cluster, and the French Croix de Guerre with Palm—retired from the Air Force on June 30, 1958, after 30 years of service.

Becomes Pilot

Born in Sugarcreek, Ohio, May 14, 1905, and graduated from Carnegie Institute of Technology with a B.S. in electrical engineering in 1928, General Putt was commissioned a second lieutenant in the Signal Corps Reserve in May of that year, and a month later was appointed a Flying Cadet in the Air Corps. After completing his flying training in June, 1929, he reported to Selfridge Field, Michigan, and was assigned to the 17th Pursuit Squadron. In September, 1930, he entered the Air Corps Technical School at Chanute Field, Illinois, graduating from the Armament course the following April. He then returned to Selfridge Field and joined the 36th Pursuit Squadron.

Ordered to Wright Field, Ohio, in February, 1933, General Putt was assigned to the Flying Branch and served as a test pilot until August, 1936, when he was assigned to the Air Corps Engineering School. Upon graduation, he entered California Institute of Technology, receiving a M.S. degree in aeronautical engineering in June, 1938. Returning to Wright Field, he held several engineering positions, including Chief of the Experimental Bombardment Aircraft Branch during development of the B-24, B-29, and B-36. From January to August, 1945, he was assigned to U.S. Air Forces in Europe as Chief, Technical Services. Returning to Wright Field in September, 1945, he was named Deputy Commanding General for Intelligence of the Air Technical Service Command. In December, 1946, he was reassigned as Deputy Chief of the Engineering Division.

Career Emphasizes R&D

Appointed Director of Research and Development in the Office of the Deputy Chief of Staff for Material at Air Force Headquarters, Washington, D.C., in September, 1948, he became Assistant Deputy Chief of Staff for Development in April, 1951.

Transferred to Air Research and Development Command at Baltimore, Md., in January, 1952, General Putt was Vice Commander, ARDC, until he assumed command of ARDC on June 30, 1953.

In April, 1954, General Putt returned to Air Force Headquarters as Deputy Chief of Staff for Development, and Military Director of the Scientific Advisory Board to the Chief of Staff, USAF.

Upon his retirement from the Air Force in 1958, General Putt served as Special Assistant to Dr. Theodore von Kármán, Director of the National Academy of Science—ARDC summer study group for the Air Force.

In October, 1958, General Putt became President of United Research Corporation of Menlo Park, a newly formed subsidiary of United Aircraft Corporation, organized to carry out research and development in the field of missiles and space technology.

General Putt is Chairman of the Scientific Advisory Board to the Chief of Staff of the Air Force and a member of the Board of Trustees of the Systems Development Corporation and The Space Education Foundation. He is an Honorary Fellow of the Canadian Aeronautical Institute and was on the National Advisory Committee for Aeronautics for 9 years. He holds membership in several honorary societies. In June, 1954, he was awarded an honorary doctor of engineering degree by the Polytechnic Institute of Brooklyn.

✦ ✦ ✦

Sir Geoffrey I. Taylor Presents Davidson Lecture

Sir Goeffrey I. Taylor (HF), Yarrow Professor Emeritus at Cambridge University, gave the first Davidson Lecture at Stevens Institute of Technology, Hoboken, N.J., November 14, on the occasion of the Davidson Medal presentation.

This new award was established by the Society of Naval Architects and Marine Engineers for distinguished achievement in ship research. It was presented posthumously to the man whose name it honors, the late Dr. Kenneth S. M. Davidson (F), and was accepted by his wife, Mrs. Katherine Davidson. Dr. Davidson was Chief Scientific Advisor, Supreme Headquarters, Allied Powers in Europe, at the time of his death in Paris in March, 1958. An internationally recognized authority on fluid dynamics, he established the Davidson Laboratory at Stevens. His 23-year career at S.I.T. produced new techniques for testing designs and was credited with the hydrodynamics research which opened the way for use of small towing tanks and models as research instruments.

The lecture—which this year was on the topic "Is There Still Scope for Simple Methods in Science?"—will be given biennially.

Conference Proceedings Available

Proceedings of the Sixth Midwestern Conference on Fluid Mechanics and the Fourth Midwestern Conference on Solid Mechanics, published as separate volumes, are now available.

These conferences, of which the IAS was one of the sponsoring organizations, were held jointly as the Midwestern Conference on Fluid and Solid Mechanics at the University of Texas, Sept. 9–11, 1959.

Copies of the Proceedings may be obtained at $12.50 per volume from Engineering Institutes, Division of Extension, University of Texas, 18th and Red River Sts., Austin, Tex.

ARDC Lab Named for Theodore von Kármán

The U.S. Air Force honored Dr. Theodore von Kármán (HF), one of the world's foremost scientists and aerodynamicists, by naming one of its major laboratories at the Air Research and Development Command's Arnold Engineering Development Center for him in dedication ceremonies at the Center on October 30.

The wind-tunnel facility was dedicated as the von Kármán Gas Dynamics Facility by Lt. Gen. Bernard A. Schriever, USAF, Commander, ARDC, in recognition of the many contributions Dr. von Kármán has made to the advancement of aerospace technology, not only in the United States but in all the free world.

Dr. von Kármán is Chairman of the NATO Advisory Group for Aeronautical Research and Development and Chairman Emeritus of USAF Scientific Advisory Board, as well as consultant to a number of industrial concerns, the Department of Defense, the Army, Navy, and Air Force.

Inspecting models at the von Kármán Gas Dynamics Facility are, *left to right*, Dr. von Kármán; General Schriever; Dr. Hugh Dryden, Deputy Administrator of NASA; Dr. J. V. Charyk, Asst. Secretary of the Air Force for R&D; and Major Gen. Troup Miller, Jr., Commander of AEDC.

FSF 12th Annual International Air Safety Seminar, 1959

The 12th Annual International Air Safety Seminar of the Flight Safety Foundation, Inc., was held in Nice, France, from October 25 through October 29, with some 250 specialists and experts on all phases of safety in flight attending.

The official delegates and observers came from 22 nations, with every continent of the world represented. Those present attended technical sessions and participated in discussions held on subjects such as the medical aspects of flight safety, current knowledge on flight fatigue, air accident investigation, aircraft operating problems research, airline safety organizations, mid-air collisions and traffic control problems, aircraft and engine manufacturers' safety organizations, search and rescue and survival, aircraft rescue beaconry, alleviation of noise as it affects safety in airport operations, and jet operations and training.

Radar reflector being held aloft during a demonstration of air-sea rescue equipment in a Zodiac outboard-motor-driven life raft containing an uninflated "offshore rescue platform."

***Left to right:* Dr. James L. Goddard, Civil Air Surgeon, FAA, and Jerome Lederer, Managing Dir., Flight Safety Foundation, at Medical Specialist Conference of the Seminar.**

Offshore Rescue Demonstrations

During the conference, a special demonstration of offshore rescue procedures was held outside the harbor off the Nice airport in cooperation with the Search and Rescue Section of the French Secretariat General of Aviation during which Capt. de Vaisseau F. Gomart acted as director. This demonstration featured an inflatable boat equipped with outboard motor which sped to the scene of a simulated air accident carrying two frogmen to assist

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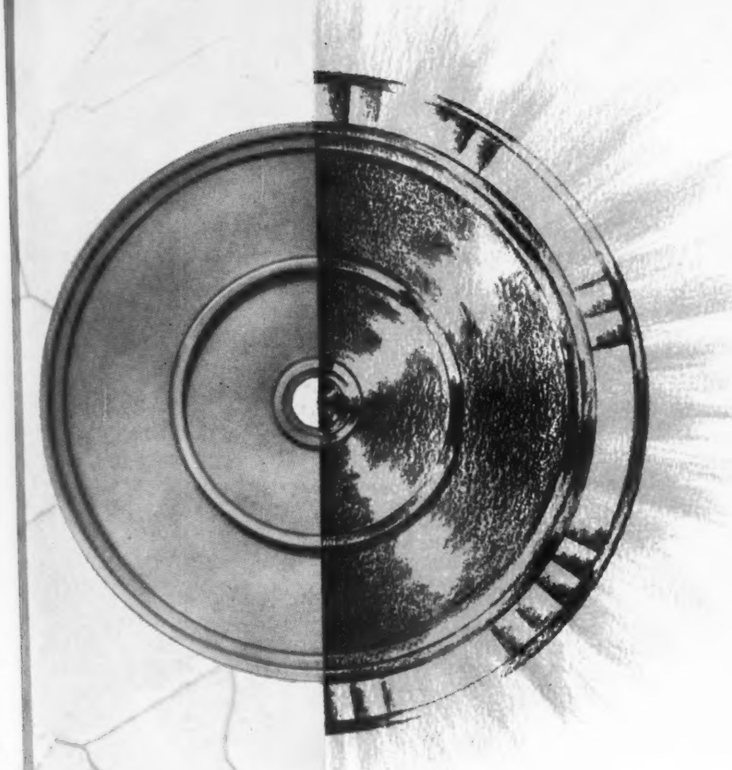

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TENSILE PROPERTIES:	Room Temp.	1400° F	STRESS RUPTURE:	Combination Smooth and Notch Bar	Smooth Bar
Ultimate Strength, psi	200,000	145,000	Temperature, ° F	1350	1650
.2% Yield Strength, psi	150,000	125,000	Stress, psi	85,000	25,000
.02% Yield Strength, psi	135,000	110,000	Life, Hours	100	50
Elongation (% in 2")	15	18	Elongation, %	12	12
Reduction in Area, %	18	20	Reduction in Area, %	14	14

Guaranteed Minimum Mechanical Properties

TENSILE PROPERTIES:	Room Temp.	1400° F	STRESS RUPTURE:	Combination Smooth and Notch Bar	Smooth Bar
Ultimate Strength, psi	180,000	135,000	Temperature, ° F	1350	1650
.2% Yield Strength, psi	132,000	115,000	Stress, psi	85,000	25,000
.02% Yield Strength, psi	120,000	100,000	Life, Hours	40	25
Elongation (% in 2")	12	13	Elongation, %	8	10
Reduction in Area, %	14	18	Reduction in Area, %	10	12

*RENÉ 41: GENERAL ELECTRIC COMPANY

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High Thrust Capacity . . . without the need for auxiliary arrangements. End-thrust loading is taken on full roller contact area, not on inner race shoulders or retaining ring surfaces.

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Relubrication in Service . . . is easy with all Shafer Bearings. Outer race groove design allows relubrication without disassembly or removal from the air frame structure, extending service life three to ten times that of ordinary aircraft bearings.

Corrosion Resistance . . . of all exposed bearing surfaces . . . is assured by cadmium plating in accordance with current applicable government specifications.

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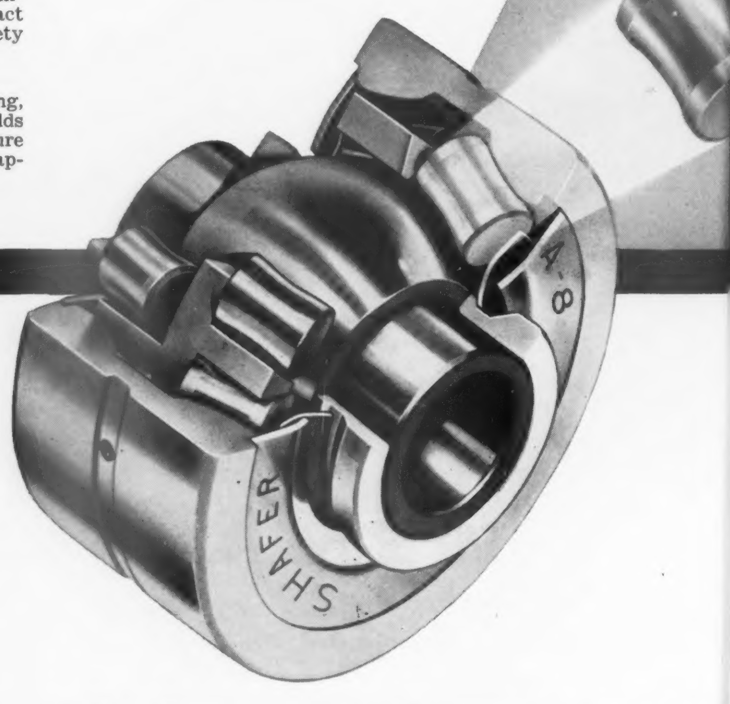

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Size for Size, a SHAFER Aircraft Bearing Has More Capacity and Reserve..Longer Serv

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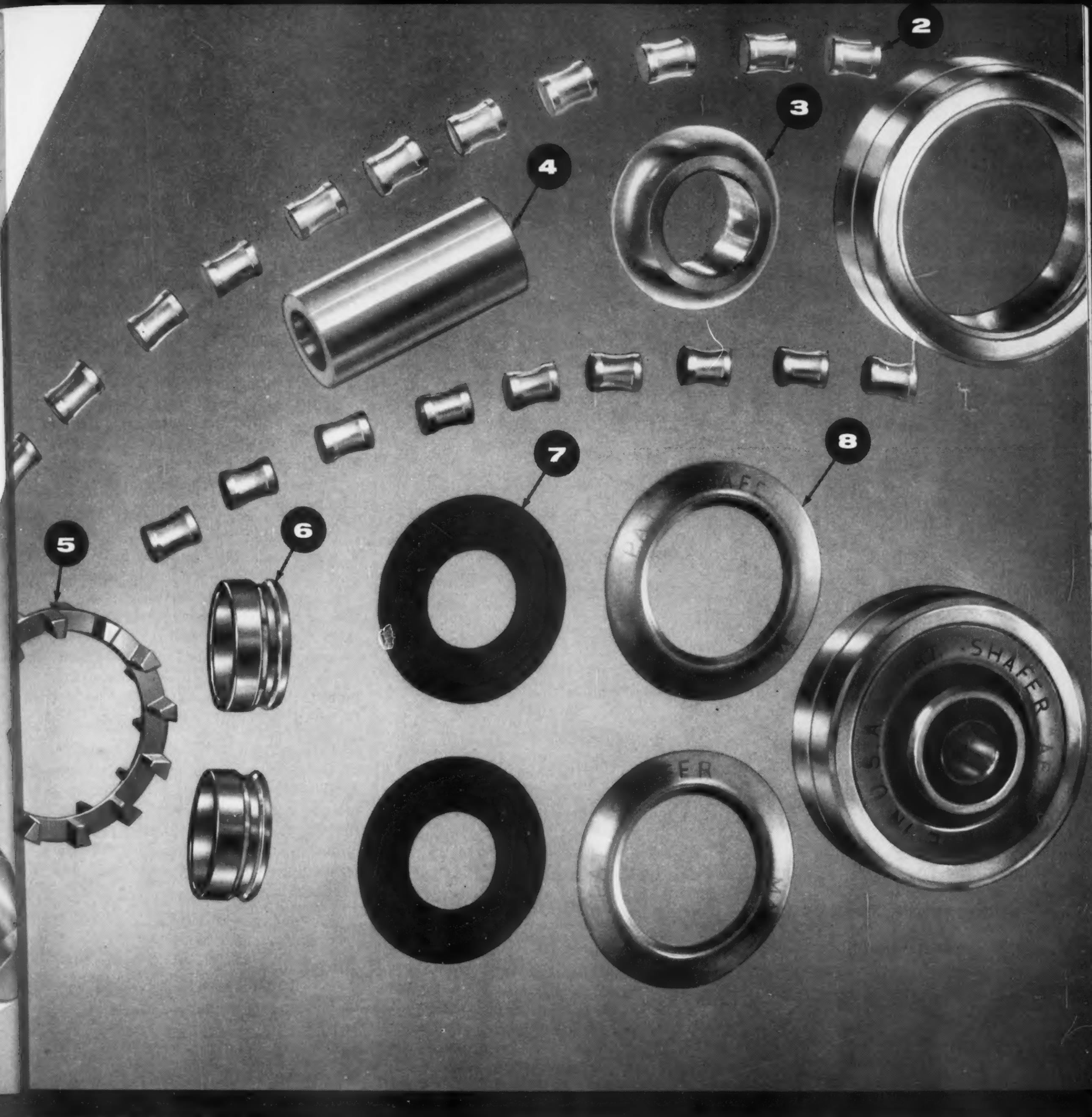


1. **Outer Race** . . . is made of SAE-52100 electric furnace bearing quality steel, heat-treated in controlled-atmosphere furnaces to produce working surfaces that are hard and tough.

2. **Rollers** . . . are of SAE-52100 steel heat-treated to assure optimum hardness and toughness. Rollers are electronically selected by size for every bearing assembly.

3. **Inner Race** . . . like rollers and outer race . . . is made, in one piece, from high-quality SAE-52100 steel heat-treated for normal service up to 300° F.

4. **Sleeve** . . . is heat-treated to provide a tensile strength of over 150,000 lb. per sq. in.

5. **Retainers** . . . for standard double-row Shafer Bearings . . . are die-cast Zamak or Beryllium Copper.

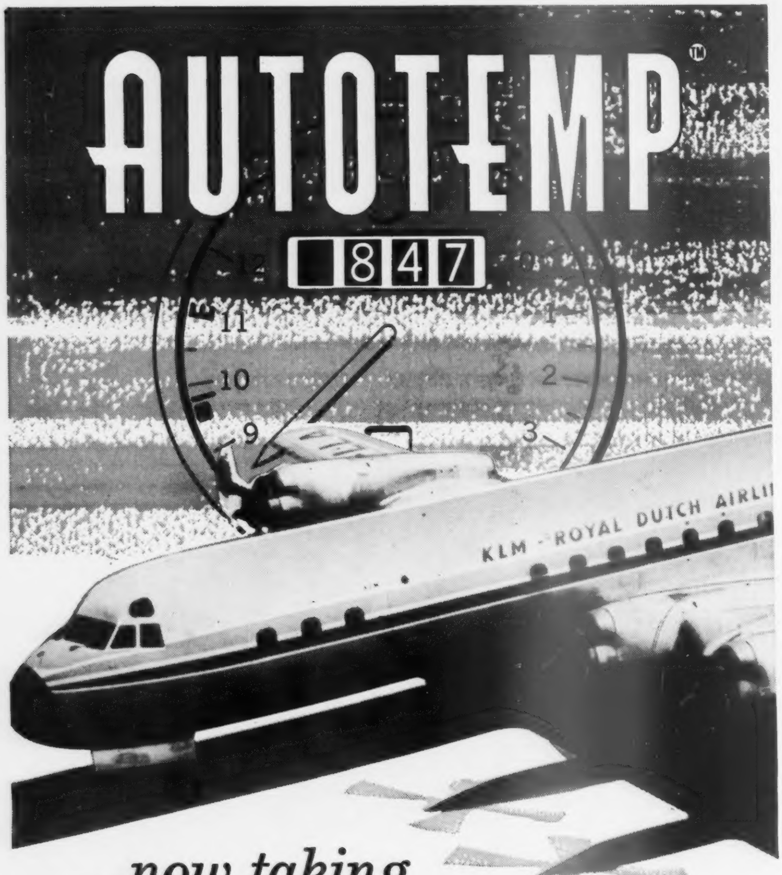
6. **Collars** . . . of high-tensile-strength steel . . . serve as spacers for inner race and alignment stops, preventing seal damage.

7. **Seals** . . . are Buna-N in all standard series, designed to permit relubrication of bearing without seal removal.

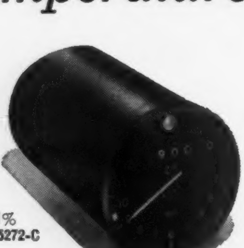
8. **Shields** . . . contour-formed of stainless steel . . . provide extra seal protection for lubricated bearing surfaces.

r Serv

Greater than Any Other Bearing of Equal Weight and Envelope Dimensions



...now taking Lockheed ELECTRA'S *temperature...to 1°C.*



Accuracy 0.1%
Meets MIL-E-5272-C

High accuracy, and easiest *needle pointer plus digital in-line counter readout,* are the principal service features of the BH183 AUTOTEMP® jet engine temperature indicator.

AUTOTEMP® is designed and produced by the makers of the JETCAL Analyzer®, the only jet engine tester used throughout the world.

The AUTOTEMP is a completely new instrument...a continuous null balance 144-inch slidewire potentiometer combined with a linearizing analog-to-digital converter. Its accuracy is the simple attribute or phenomenon of its novel and basic slidewire potentiometer!

Self-contained...silicon-transistorized, miniaturized, hermetically sealed, servo-driven...the AUTOTEMP's 3"-diameter case includes a Zener reference, power supply, amplifier, servo motor, cold junction compensation and the 144-inch slidewire and punched tape to linearize thermocouple e.m.f. for exact, counter-type digital readout. The needle pointer indicates in 50°C increments over the 0 to 1200°C full range of the unit.

Full information is contained in our Bulletin BH183 available for the asking!

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survivors, the retrieving of crash survivors from the seas by helicopter, and the inflation at sea of a new rescue platform level with the ocean's surface at one end to enable survivors to climb aboard more easily.

Among the most important probable future safety advances pinpointed during the Seminar discussions were the organization of a common air traffic control system for the continent of Europe, the increased employment of devices similar to one already in use by Canada's Department of Transportation to clear airport runways completely of both snow and slush through the utilization of jet blasts, and the greater use of inflatable mattresses and similar equipment of a type which can be sped at high speed on the surface to the scene of an offshore crash.

Dr. Otto Kirchner of Boeing delivered a paper carefully defining previously hazy areas connected with approach and landing accidents responsible in the past for a large percentage of all fatal accidents in commercial airline operations. He undertook, and is currently working on, this approach and landing accident investigation project for the Flight Safety Foundation.

Although all talks and discussions at the Seminar, except Lord Balfour's speech at the Dinner, were "off the record" and not for general publication, the Flight Safety Foundation plans to publish a general summary of the proceedings including technical and scientific highlights.

✦ ✦ ✦

IAS Fellow Receives Metals Society Award

John L. Atwood (F), President of North American Aviation, Inc., was awarded the 1959 Medal for the Advancement of Research by the American Society for Metals. Presentation was made at the National Metals Exposition and Congress in Chicago in November.

Mr. Atwood was selected to receive the award on the basis of his leadership at North American, under which the company has made great progress "in the development of chemical milling and electrochemical milling, and pioneered in the use of titanium and in such advanced forming methods as 'explosive forming.'"

Technical Motion Pictures

If you need information about Technical Motion Pictures—consult the IAS Technical Film Catalog.

This Catalog is an authentic up-to-date listing of motion pictures in fields of interest to the Air Force and is being compiled under contract with the Air Research and Development Command. There are

4,800 classified and unclassified films listed to date, and approximately 100 new titles are added each month.

One set of the Catalog cards is maintained in the IAS Building at 2 E. 64th St., New York 21, N.Y. Members may obtain information by consulting the Librarian. The master set is located at the IAS office at 3380 N. Harbor Dr., San Diego 1, Calif. Bibliographies covering specified subjects will be furnished from the San Diego office upon request.

IAS Members Honored by ARS

Twelve IAS members were among those receiving awards at the 14th Annual Meeting of the American Rocket Society in November.

Recipients of awards for outstanding contributions to space flight and rocket propulsion were Ali Bulent Cambel (M), Chairman, Mechanical Engineering Dept., Northwestern Univ.—The G. Edward Pendray Award for contribution to rocket and astronautical literature; Walter Dornberger (AF), V-P—Engineering, Bell Aircraft Corp.—The ARS Astronautics Award for contribution to the advancement of space flight; and Karel J. Bossart (AF), Asst. to the V-P—Engineering, Convair-San Diego—The James H. Wyld Memorial Award for application of rocket power.

Awarded Fellow memberships in the Society were Walter T. Olson (AF), Chief, Prop. Chem. Div., Lewis Res. Center, NASA; Lester Lees (AF), Prof. of Aeronautics, Guggenheim Aero. Lab., C.I.T.; William Avery (AF), R&D Supervisor, APL, Johns Hopkins Univ.; Homer J. Stewart (F), Dir., Office of Program Planning and Evaluation, NASA; William G. Purdy (M), Dir., Plans and Programs Div., Martin Co.; T. Keith Glennan (HM), Administrator, NASA; Richard D. Geckler (AF), V-P, Solid Rocket Plant, Aerojet-General Corp.; Kurt Berman (M), Mgr., Engrg., Rocket Sect., FPD, G-E; and James J. Harford (A), Exec. Secy., ARS.

Ramo-Wooldridge New Corporate Member

Ramo-Wooldridge, new IAS Corporate Member, is a division of Thompson Ramo Wooldridge Inc. It is an integrated organization for research, development, and manufacture in the field of electronic systems for commercial and military applications. Total employment at the end of July, 1959, was 2,550. The professional, scientific, and engineering staff comprises 525 members.

In the aerospace field, Ramo-Wooldridge is engaged in work in a variety of areas including missile electronics systems, information processing systems, advanced radio communications systems, air navigation and traffic control, analog and digital computers, infrared systems, electronic reconnaissance and countermeasures, and basic and applied physical research.

News of Members

Rudolph Bodemuller (M), formerly Manager of the Systems Development Dept., has been appointed Director of Engineering in the Aircraft Section of Bendix Products Div., Bendix Aviation Corp.

Richard G. Bowman (AF) has been named Technical Assistant to the President of Republic Aviation Corp. Mr. Bowman has been with Republic in various engineering posts since 1935.

Boyd Dahle (M) has been appointed Chief Engineer of Sierra-Schroeder Div. of Idaho Maryland Mines Corp. of Glendale, Calif. Mr. Dahle was formerly Chief Engineer of the Air-Gas Valve Div. of Parker Aircraft Co.

N. F. Frischhertz (M), formerly Manager, Product Support, Production Engine Dept., has been named Manager, J79 Engineering Project, Jet Engine Dept., General Electric Co.

Frederic E. Fuller (M) has joined Electro-Optical Systems, Inc., as a member of the Senior Technical Staff, assigned to the Energy Research Div. Prior to his new position, Dr. Fuller was a Technical Specialists for Aerojet-General Corp.

Robert M. Gitlin (M) has been appointed Manager of Engineering for the East Coast plant of Fairchild Controls Corporation's Components Div., a wholly owned subsidiary of Fairchild Camera and Instrument Corp. Prior to his new position, Mr. Gitlin was Head of the Air Data Systems Section of Kollsman Instrument Corp.

R. Paul Harrington (AF) has been appointed Professor and Head of the Department of Aeronautical Engineering in the University of Cincinnati's College of Engineering. He will replace the late Prof. Roy H. Murray. Dr. Harrington was formerly Professor of Aeronautical Engineering at Rensselaer Polytechnic Institute, having previously served as Technical Director of NATO's Training Center for Experimental Aerodynamics near Brussels, Belgium.

John R. MacGregor (AF) has been elected a Vice-President and Director of California Research Corp., a subsidiary of Standard Oil Co. of California, to succeed J. L. Cooley who retired recently. Mr. MacGregor joined Standard Oil's R&D Dept., California Research Corporation's forerunner, in 1925.

Martin Goland (AF), formerly Director, has been elected President of Southwest Research Institute. He succeeds Harold Vagtborg who has been named Executive Chairman of the Institute's Development Council.

John V. N. Granger (M), President of Granger Associates in Palo Alto, Calif.,

Necrology

Alfred A. Gassner

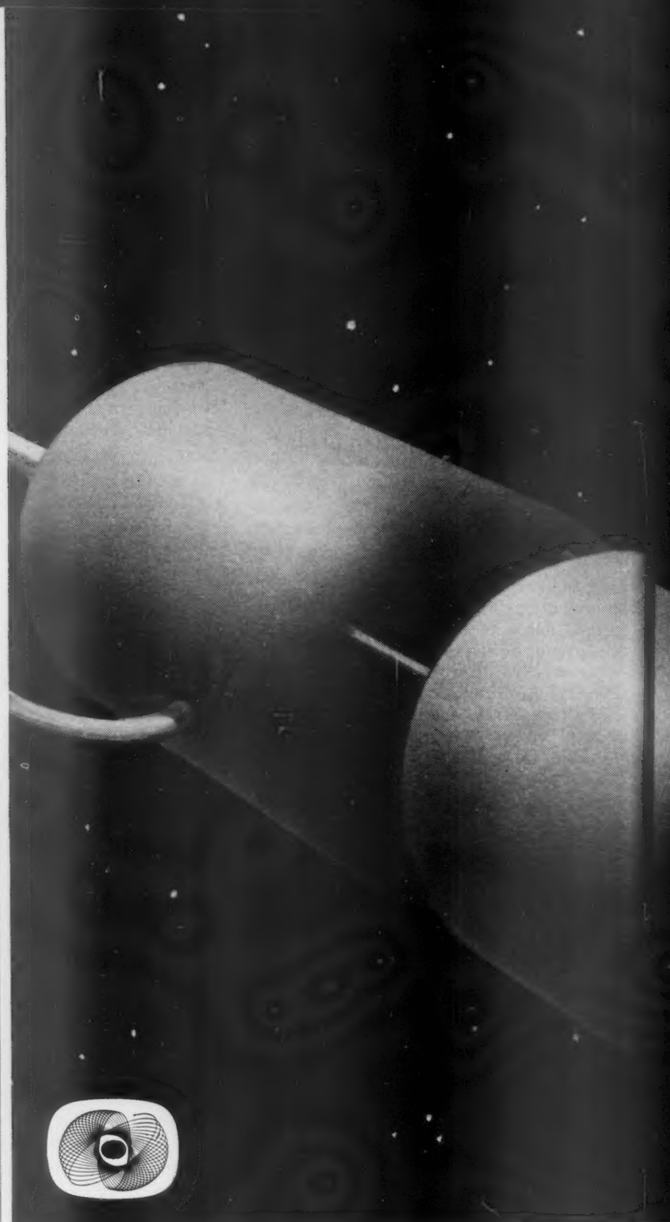
News of the death of Alfred A. Gassner (AF) on October 25, 1959, has been received by the Institute. He was 67.

Mr. Gassner was head of Gassner Engineering in New York City. Born in Austria and educated at the Technical University in Vienna, Mr. Gassner had been associated with several firms in Austria and in this country, including Fokker Aircraft Co. and what was then Fairchild Aviation Corp. in Hagerstown, Md., before forming his own firm in 1937.

Lt. Comdr. Richard A. Mergl, USN

Lieutenant Commander Richard A. Mergl, USN (A), was killed in a military aircraft accident over Lake George, Fla., on April 22, 1959. He was 31 years old.

Commander Mergl was a 1949 graduate, with a B.S. degree, of the U.S. Naval Academy, and in 1956 received a B.S. degree in Aeronautical Engineering from the U.S. Naval Postgraduate School, Monterey, Calif.



Here is Aldrich Zmeskal, Manager of Balloon Engineering, observing the launching of another General Mills balloon —one of thousands which we and our customers have flown in the past few years. This routine flight was for the purpose of obtaining samples of radioactive material from the stratosphere. Through our balloon research projects, we have amassed a considerable fund of knowledge valuable to future space flight.

General Mills know-how can help today

The Mechanical Division provides "floating laboratories," balloons carrying heavy payloads of equipment—and even men—to altitudes above 95% of the earth's atmosphere. This is a relatively easy and inexpensive way to obtain the knowledge which will enable man to travel in space.

Our many research activities cover broad areas in physics, chemistry, mechanics, electronics and mathematics. Some of the studies representative of these activities are: ions in vacuum, deuterium sputtering, dust erosion, magnetic materials, stress measurements, surface friction and phenomena, trajectory data and infrared surveillance.

In our engineering department, current projects include: specialized inflatable vehicles and structures, airborne early warning systems, micro wave radar test equipment, antennas and pedestals, infrared and optics,

Manned vehicle refueling in space . . . illustration from book written for General Mills by Willy Ley.

. to make space travel a fact tomorrow

inertial guidance and navigation, digital computers—and many other activities.

Our entire manufacturing department is geared to produce systems, sub-systems and assemblies to the most stringent military requirements. Our people have a wealth of experience in the most complex military projects.

Write for free booklets: (1) Complete research, engineering and manufacturing capabilities of the Mechanical Division (2) New booklet on General Mills balloons.

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General Mills

Angelo Miele (AF) has joined Boeing Airplane Company's Scientific Research Lab. as Director of Astrodynamics and Flight Mechanics. He was formerly Professor of Aeronautical Engineering at Purdue University.

has joined the Board of Directors of Wescon (Western Electronic Show and Convention). Serving for 4 years, Dr. Granger will sit on the eight-man board directing policies of the trade show-convention.

J. S. Harris (A), formerly Manager of Shell Oil Company's Aviation Dept., has been named Manager of the newly formed Products and Commercial Sales Group in the company's marketing organization.

E. Haynes (AF) has been appointed Program Manager, Exploratory Research, Advanced Research Projects Agency. Mr. Haynes was formerly Deputy Director of Aeronautical Sciences, AFOSR.

Nicholas J. Hoff (F), Head of the Dept. of Aeronautical Engineering at Stanford University, has been named to the Scientific Board of Directors of Vidya, Inc., a research and development firm in Palo Alto, Calif.

R. E. Honer (M) has been named Manager of the newly established Convair-San Diego Electronics. Mr. Honer was formerly Assistant Chief Engineer for Electronics.

A. A. Lakner (M), formerly a Design Specialist with Fairchild Aircraft Div. of Fairchild Engine & Airplane Corp., has joined Lockheed Aircraft Corp. in Marietta, Ga., as a Reliability Representative.

Arthur E. Miller (M), Director of Research, Scott Aviation Corp., has been elected to the company's Board of Directors.

Alain Mona (A), formerly Stress Analyst with Flugh- & Fahrzeugwerke A.G., Altenrhein, Switzerland, has joined Messrs. Contraves S.A., in Zurich, as an Aerodynamics Engineer.

John L. Orr (M) has been appointed a Canadian National Delegate to AGARD.

Leo A. Pfankuch (M) has been promoted from General Manager to Vice-President in charge of the Anaheim Div. of the Pacific Scientific Co.

Andre W. Reichel (M), Director of Sales and Service, has been named Vice-President of the Aeronautical Div. of the Pacific Scientific Co.

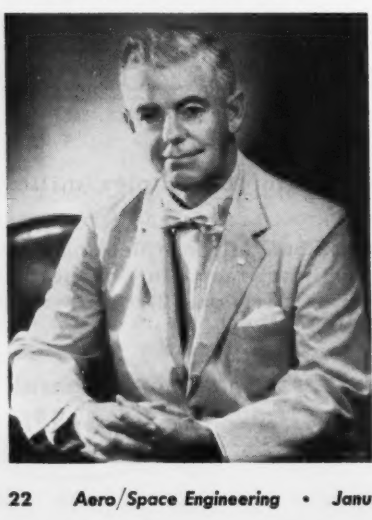
Iden F. Richardson (M) has been appointed Manager of Hughes Products Group, a division of Hughes Aircraft Co., succeeding Raymond B. Parkhurst who will resume his former post of Vice-President—Manufacturing. Prior to joining Hughes in August, 1959, Mr. Richardson had been General Manager of the Kansas City Div. of Bendix Aviation Corp.

James D. Redding (AF) has been named Director of Military Applications of Remington Rand Univac, Div. of Sperry Rand Corp. Mr. Redding had been Marketing Manager of the Aviation Gas Turbine Div. of Westinghouse Corp.

Robert E. Ricles (AF) has joined Republic Aviation Corp. as Specialist Aeronautical Engineer. Mr. Ricles was formerly Manager, Advanced Re-Entry Vehicle Projects at AVCO Research and Advanced Development.

John H. Sidebottom (M) has been appointed Administrator, Marketing Staff, Defense Marketing, Defense Electronic Products, of the Radio Corporation of

Frederick F. Robinson (A), President and Director of National Aviation Corp., has been elected a Director of Collins Radio Co.



Meet the Staff

An Aero/Space Engineering feature on personnel of the Institute of the Aeronautical Sciences

Raymond Sterling—"*Man of Note(s)*"

Raymond A. Sterling came with the Institute in March of 1943 as Assistant to Controller Joseph J. Maitan.

Among his first assignments was working with the Controller's Office to strengthen the Accounting Department and to effect several changes demanded by the aeronautical industry's busy war years. His duties today remain those generally associated with accounting practices.

One of those rare native New Yorkers, our January Meet the Staff subject attended Fordham University to study business administration.

Orphaned early in life, Ray was raised by Andrew B. Sterling, one of the country's leading composers of such songs as "Wait 'Til the Sun Shines Nellie," "On a Sunday Afternoon," "When My Baby Smiles at Me," and hundreds of others.

It is small wonder, then, that Ray's hobby became music. Today he is a recognized composer and lyricist, a writer member of ASCAP, and author of "The Helicopter Song," written for and dedicated to the American Helicopter Society. —A.B.

Versatile Ground Support for Jet Transport Fleets

Ground Power Flyaway Unit

Ground Power Vehicle

Ground Power Trailer

8,500 AiResearch Gas Turbine Units in Use

Extremely reliable and diversified, AiResearch mobile ground support equipment provides main engine starting for turbine-powered aircraft, and ground air conditioning and electrical power for both aircraft and missiles.

Heart of the lightweight ground support systems are AiResearch gas turbine compressors which provide pneumatic and/or electrical power. Electrical power is supplied when the unit is coupled with an alternator.

GROUND POWER FLYAWAY UNITS for jet engine starting are designed to meet the need for a mobile low cost pneumatic power source which is readily air portable for emergency use. These lightweight, self-contained units are mounted on a compact cart complete with instrument panel and enclosure. They can also be used for missile ground support where pneumatic power is required.

GROUND POWER VEHICLES supply both pneumatic and electrical power for jet engine starting, ground air conditioning and other ground requirements where these types of power are needed. Air and electrical connections located at the front of the vehicle allow the operator to drive frontward into position. The instrument and control panel are inside the cab, and the power unit is easily accessible through wide doors on both sides of the vehicle. Full sound attenuation reduces operating sound level below 90 decibels at a distance of 10 feet.

GROUND POWER TRAILERS provide pneumatic power for jet engine starting on ground air conditioning... and electrical power when equipped with an alternator. These rugged, completely self-contained units are also fully sound attenuated. Servicing is easily accomplished through ample access doors.

AiResearch ground support equipment can be designed to meet specific requirements or installed on standard vehicles. Your inquiries are invited.

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AiResearch Manufacturing Divisions

Los Angeles 45, California • Phoenix, Arizona

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America. Prior to his new position, Mr. Sidebottom was Executive Vice-President of Industrial Acoustics Co. and Director of Sales of the Wright Aeronautical Div. of Curtiss-Wright Corp.

Franklin C. Spinney (M) has been named Manager of Research Sales for the Allison Div. of General Motors Corp. Mr. Spinney was formerly a Field Engineer in the Division's Washington Zone Office.

Charles H. Webber (M), formerly Vice-President, has been named Executive Vice-President of the Pacific Scientific Co.

J. D. Wethe (M) has been named Acting Manager—Marketing, Production Engine Dept., General Electric Co. Mr. Wethe was formerly Manager—Operations Analysis for G-E.

John M. Wild (M) has joined General Dynamics Corporation's General Atomic Div. as Director of Project Orion and Assistant Director of the Division's John Jay Hopkins Laboratory for Pure and Applied Science. Mr. Wild has been Director of Engineering for A.R.O., Inc.

IAS *News* — *Corporate Member News*

• **Aerojet-General Corp.** has appointed Norvin E. Erickson as Base Manager for its operations at the Air Force Missile Test Center, Cape Canaveral, Fla. Mr. Erickson replaces the late Thomas F. Rocco.

• **Aeronca Manufacturing Corp.** has announced the regrouping of all its Pacific Coast activities into the newly organized Aerocal Div. with its headquarters in Torrance, Calif. George M. Ebert has been named Vice-President and General Manager of the new division.

• **Aeronutronic,** a Div. of Ford Motor Co., has named John C. Christian, former Staff Consultant of Market Development for Hughes Aircraft Co., as Manager of Marketing for Space Technology Operations.

• **Avien, Inc.,** has elected Norman C. Pickering to its Board of Directors, replacing Henry W. Blackstone who recently resigned. Mr. Pickering joined Avien in February, 1959, as Vice-President and Technical Director. Avien also appointed Leon E. Kornbleet as Manager of Industrial Relations. Before joining Avien, Mr. Kornbleet was Manager of Industrial Relations for Diamond Brothers Co., Inc.

• **Bendix Aviation Corp.** has announced the election of R. C. Fuller, General Manager of its Pacific Div., as Vice-President and Group Executive of the Corporation and member of the Corporation's administration Committee. . . . Utica Div. has announced three promotions in its engineering personnel. Howard A. Alexanderson, Chief Engineer of the Division since 1951, was named Director of Engineering. Bernard Goldberg, Executive Engineer since 1954, was appointed Chief Engineer, Current Products. Henry Troeger, a Supervisory Engineer since 1956, was named Chief Engineer, Advance Design.

• **Borg-Warner Corp. . . .** Weston Hydraulics, Limited, West Coast subsidiary of Borg-Warner, formally opened its new 100,000 sq. ft. plant in Van Nuys, Calif., on October 29.

• **Chance Vought Aircraft, Inc.,** through stock purchases, has acquired a majority interest in National Data Processing Corp. NDP will maintain its autonomy.

• **Chicago Aerial Industries** has acquired the Pacific Optical Corp., which will operate as a separate division of CAI.

• **Collins Radio Co.** has appointed Herbert J. Pyle to the newly created position of Director of Service of the Cedar Rapids Div. Mr. Pyle was formerly Vice-President of Precision Instrument Laboratories.

• **Eastern Air Lines, Inc.,** commenced operations at its new passenger terminal at New York International Airport, Idlewild, on October 29.

• **Fairchild Engine and Airplane Corp.** has announced the appointment of Cregg Coughlin as Assistant to the President to represent Fairchild in Washington.

• **The Garrett Corp.** has appointed Robert M. Jackson as Assistant to the Vice-President in Charge of Sales. Prior to his new assignment, Mr. Jackson was a Department of Defense Electronic-Management Engineer for 20 years.

• **General Dynamics Corp. . . .** Convair Division's Fort Worth plant has created a new research section as part of the Engineering Dept. The new section, which will be headed by Dr. E. Leigh Secrest, will be devoted to the physical sciences of advanced projects, including space exploration.

• **General Electric Co. . . .** Defense Systems Dept. has named Roy J. Graeter as Manager of Electronic Engineering in its newly created Special Programs Section. Prior to his new assignment, Mr. Graeter was a Consultant with the Company's Heavy Military Electronics Dept.

• **General Motors Corp. . . .** AC Spark Plug Div. has named Ervin L. Penkalski Director of its Santa Monica facility, located at Douglas Aircraft Co.

• **General Precision Laboratory Incorporated,** a subsidiary of General Precision Equipment Corp., has appointed Frank A. McMahon Manager of the Service and Support Dept. Dr. McMahon was formerly Manager, Field Service and Training Section.

• **ITT Laboratories** has appointed J. Lane Ware Associate Laboratory Director, Avionics Equipment Laboratory. Before joining ITT, Mr. Ware was Chief Engineer of the Aviation Engineering Dept. of Bendix Radio Div.

• **Kearfott Co., Inc.,** has appointed Willard A. Hughes General Manager of its Microwave Div. Mr. Hughes was previously Assistant General Manager of the division.

• **Walter Kidde & Co., Inc.,** has appointed Donald J. McCaffrey Central Atlantic District Manager for its Aviation Div. Mr. McCaffrey has been with Kidde since 1951.

• **Lear, Inc.,** has named Ivar C. Peterson Assistant to the President to direct and supervise technical planning. Mr. Peterson was formerly Director of Technical Services for Aerospace Industries Association.

• **Lockheed Aircraft Corp. . . .** Missiles and Space Div. has set up a new facility for the Midas satellite system at Cape Canaveral. The base has been activated to handle only the R&D phases of the Midas satellite system.

• **The Martin Co. . . .** Nuclear Div. has appointed Mostafa B. Talaat Director of Energy Conversion R&D. Prior to joining Martin, Dr. Talaat was associated with the Carrier Research Center.

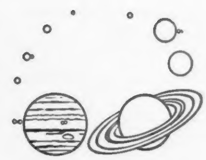
• **Northrop Corp.** has elected Howard P. Robertson, Professor of Mathematical Physics at the California Institute of Technology and a member of President Eisenhower's Scientific Advisory Committee, to its board of directors.

• **Republic Aviation Corp.** has announced two recent special appointments. Carver T. Bussey, a 21-year Air Force veteran, has been named Special Assistant to the President. Samuel Lubkin, formerly Manager of Digital Computer Development for the Electronics Div. of Curtiss-Wright Corp., has been named a Staff Consultant to the Missile Systems Div.

• **Solar Aircraft Co.** has appointed Bertram Klein as Chief of Structures. Mr. Klein has previously held structures engineering positions at Douglas Aircraft Co., Inc., Bell Aircraft Co., and North American Aviation, Inc. Hans W. Weickardt has been named Section Chief of Stress Analysis in the R&D Engineering Div. at Solar. Mr. Weickardt was formerly Chief of Stress Analysis with Brown Engineering Corp.

• **Vertol Aircraft Corp.** has announced the appointment of Frank K. MacMahon as Manager of Military Programs, and D. W. Dickinson as Military Relations Administrator in the Military Programs Dept. Mr. MacMahon was formerly Acting Manager of the Department, while Mr. Dickinson had been Chief Pilot for Keystone Helicopter Corp. Vertol also named John B. Moss, formerly President of Hoffman Laboratories Div. of Hoffman Electronics Corp., as Assistant to the President.

Douglas engineers spin new cocoons for tomorrow's space travelers



Space researchers in human factors engineering utilize latest discoveries of medical science

Each time a space traveler leaves home (earth) he has to be completely wrapped in a special environment. He needs it to survive under alien conditions such as extreme heat and cold, high vacuum, cosmic radiation and tremendous G forces.

At Douglas, life scientist research over the past ten years has explored more than *forty* basic factors relating to human survival in space. Douglas engineers are now completing — at military request — a careful survey of conditions that will be encountered en route to and on other planets. They are also evolving plans for practical space ships, space stations and moon stations in which men can live and work with security thousands of miles from their home planet.

Out of these research activities and those made by companion workers in this field has come new knowledge of great medical importance... even to those of us who are earthbound.

DOUGLAS

MISSILE AND SPACE SYSTEMS • MILITARY AIRCRAFT • DC-8 JETLINERS • TRANSPORT AIRCRAFT • AIRCOMB • GROUND SUPPORT EQUIPMENT

IAS Sections

Baltimore Section

Equipment Research Director Evaluates 707

Franklin W. Kolk (AF), Director of Equipment Research for American Airlines, discussed "**American Airlines Experience With the Boeing 707**" at the October 22 dinner meeting.

Mr. Kolk, accompanying his presentation with slides, gave insight into engineering and operational planning behind the scenes. He discussed take-off and landing procedures and the variables which affect ground run and schedule. Various intended airplane modifications that will increase performance, cruise altitude, and range were mentioned—as, for example, the turbofan engine installation.

Mr. Kolk said that, in general, the 707 airplane has to date been an outstanding operational success. The amount of missed schedules due to ground delays will improve, and engine reliability has been remarkable.

A question-and-answer period followed Mr. Kolk's talk.

L. K. FERO, *Secretary*

Chicago Section

Jupiter "C" Nose Cone Recovery

Dr. Charles H. Rockwood, Staff Engineer of Cook Research Laboratories, gave a talk entitled "**First From Space**" at the October 28 dinner meeting. Dr. Rockwood, formerly Project Engineer responsible for the program, told of the progress and many tests performed to achieve a successful recovery kit for the Jupiter missile nose cone.

In operation of this kit, a parachute is opened at approximately 11,000 ft. altitude to slow the descent and lessen impact upon hitting water, when a neoprene ball inflates and acts as a float for the nose cone. The balloon is traced by radio signals that it transmits, its own dye marker, two small explosions, and its bright color.

The presentation was illustrated by movies of dummy tests and actual recovery of the first nose cone. A question-and-answer period followed the formal discussion.

MILES J. MRAZ, *Secretary*

Columbus Section

Consolidated Maintenance Techniques in SAC Operations

Captain Jimmie R. Osborne, USAF (M), Section Maintenance Officer of the 367th Operational Maintenance Sq., Lockbourne AFB (SAC), USAF, was the principal speaker at the October 21 dinner meeting. Captain Osborne based his discussion, "**Consolidated Maintenance Techniques in SAC Operations,**" on maintenance organization and problems, including some odd effects of extreme climates, and on crash investigations.

Featured at the meeting was a tour of Lockbourne AFB directed by Sgt. Danny Klimovich, Information Service Office, who also gave a talk on his flying experiences as a Senior Pilot and combat veteran.

JAMES P. LOOMIS, *Secretary*

Detroit Section

VTOL-STOL Panel Meeting and Display

The past history of the Michigan Department of Aeronautics, its purpose, organization, and future plans for the development of aviation facilities in the State of Michigan was discussed by the Hon. **Harry J. Phillips,** State Representative, before the October 13 dinner meeting. The meeting, held in cooperation with Aviation Activity, Engineering Society of Detroit, and the Michigan Aeronautics and Space Association, featured a panel discussion which followed Mr. Phillips' presentation.

This discussion, moderated by Program Chairman Peter Altman of Continental Motors Corp., presented various aspects of VTOL/STOL aircraft. Edwin Stopler, Senior Component Development Engineer, Sikorsky Aircraft Div., United Aircraft Corp., presented a paper entitled, "**The Helicopter Crane as a Prime Mover**" for **M. A. Wachs,** Chief of Component Development at Sikorsky. Mr. Stopler described the development of Sikorsky S-60 helicopter crane as an outgrowth of a building block concept utilizing the engine installation, main landing gear, and mechanical components of the S-56 (Army H-37, Marine HR2S-1) helicopter. His paper outlined the purpose and advantages of the S-60 and was supplemented by a short color film depicting a typical mission, setting up a mock missile base in an inaccessible area.

Marvin D. Marks, Chief Engineer, Helicopter Engineering Div., McDonnell Aircraft Corp., presented a paper which outlined a theoretical method for the selection of the proper VTOL configuration for a given mission (range, load, speed, and altitudes). It compounded the various attributes of the pure helicopter, partially unloaded rotor, fully unloaded rotor, and "airplane type" VTOL-STOL configurations with a conclusion as to the most promising version.

Phillip W. Letts, Jr., Chief Engineer, Defense Engineering, Defense Products Div., Chrysler Corp., presented a paper which separated the many VTOL-STOL configurations into three general groups (ground effect, observation, and transport). Dr. Letts described the purpose and advantage of each and outlined their present state of development by means of a film showing these many configurations in prototype and development tests.

The final paper was presented by **Carl F. Bachle,** Vice-President in Charge of Research, Continental Aviation and Engineering Corp., who spoke on "**Power Plants for VTOL-STOL Aircraft.**" Mr. Bachle outlined the advantages and disadvantages of many types of power plants and configurations for VTOL applications. To clarify the descriptive materials, slides of operational or proposed units of each of the various configurations were presented.

Exhibits included displays by Chrysler Corp. (models of flying platforms); Kelsey-Hayes (helicopter drive train gear elements); Continental Aviation and Engineering Corp. (gas-turbine engine); Parsons Corp. (rotor blades); Allison Div., General Motors Corp. (Model 250 aircraft gas-turbine engine); and Vickers, Inc. (hydraulic equipment).

Section officers for the 1959–60 season are Chairman, Fred Wilhoff; Vice-Chairman, William Spreitzer; Secretary, Frank L. Moncher; and Treasurer, Donald J. Ritchie.

FRANK L. MONCHER *Secretary*

Hagerstown Section

Some Thoughts on VTOL Propulsion

The next generation of transport airplanes might well be VTOL's which would be used for short-haul, intercity use. This was the guess ventured by **Peter Kappus** (AF), Manager, New Products Planning, FPLD, General Electric Co., at the October 21 dinner meeting. Elaborating on this guess, Mr. Kappus listed overall economy, mechanical simplicity, and a lightweight engine as the basic requirements for this type of airplane.

He discussed the need for new power plants specifically designed for VTOL aircraft to achieve optimum designs, and described some future VTOL designs with integrated power plants.

Mr. Kappus described G-E's approach of using an engine that provided both vertical lift and forward thrust without tilting the power plant. These jet engines, by using deflecting vanes and pneumatic coupling, were used to drive lift fans that were buried in the wings. Regulation of the engine jet stream between the tip-driven fan and a conventional jet tailpipe discharge provided a smooth transition from vertical lift to forward propulsion. Pictures of a proposed small VTOL transport using these engines were shown. A test stand for static testing of one of these new engines is now being completed at the G-E plant.

J. C. MAYCOCK, *Secretary*

Kansas City Section

Milestones in the History of Science

Joseph C. Shipman, Director of the Linda Hall Library in Kansas City, traced the history of science from the ancient Greeks to Einstein illustrating his theme that the best acquaintanceship with science is through its history, at the October 27 dinner meeting.

Mr. Shipman stated that science is an essential part of our heritage, having the

(*Continued on page 104*)

DATELINE world

PROFESSIONAL NOTES AND REPORTS

Engineering and Scientific Briefs from Correspondents Around the Globe

Poles Start Production on Electronic Milling Machine

◆A heavy equipment plant in Pruszkow, Poland, has started production on an electronically controlled milling machine that will be used mainly in plastics and rubber processing.

Meanwhile, according to a Budapest paper, the first Soviet installation for controlling a boiler-turbine power unit by means of an electronic computer is ready to operate in a power plant in Kharkov. The equipment consists of an information system, devices for regulating and correcting operation of the power unit, and other mechanisms. The computer starts and stops the power unit, makes necessary modifications in cases of damage, and records technical data.

Extensive Improvements Made to Hungary's Ferihegy Airfield

◆ Hungary's Ferihegy Airfield, near Budapest, has undergone extensive improvements this year. Not only has the runway been lengthened to 3,010 meters, but GCA equipment with VHF direction finder purchased from the U.S.S.R., and a modern ILS system, have been put into operation. The aerodrome control and approach services performed by the 118.1-mc. VHF control tower were to be separated, and a new VHF was to be introduced for the latter facility. A 200-km.-range radar control center was to be established, as was a multichannel tape recorder. Czechoslovakia was to furnish modern airport lighting equipment. According to report, the time interval for landing two aircraft under IFR conditions was reduced from 10 to 5 min. by modifying the pattern system at this important airport.

East Germans Building Mammoth New Telescope

◆ A new mirror telescope under construction at the Zeiss Plant in Jena will be completed by next summer, according to a press release from East Germany. It is claimed that the new instrument will be the third largest telescope of its kind (*Announced size indicates fifth largest*—Ed.), but will be superior to the world's largest telescope at Palomar in that it will for the first time combine four optical systems—the Schmidt, Newton, Cassegrain, and Coude mirrors. Thus the instrument is equally suitable for both astrography and spectography. According to the description furnished in the announcement, the mirror has a diameter of 2.08 m. (81.9 in.), a thickness of 32 cm., and was ground from a glass block that weighed 2,350 kg. The telescope, which will float on a thin layer of oil and will turn by means of changing oil pressure, is said to weight 84 tons.

Installation will be made in a new institute which is being built in the Tautenburger Forest near Jena, and which will be available to astronomers from all over the world. Opening date has been scheduled for August 1, 1960, the occasion of the International Astronomical Conference in Jena.

Computers Credited With Lunik Successes

◆ V. I. Siforov, Corresponding Member of the U.S.S.R. Academy of Sciences, stresses that both Luniks II and III were successful only because of the accurate performance of the electronic computers, by means of which trajectories were calculated. He emphasizes that the second cosmic rocket would have missed the moon had the actual velocity deviated from the calculated one by even 1/100 of 1 per cent. In connection with the third rocket, he points out: "For the first time in the history of mankind, the command into the black remoteness of the cosmos is being sent from a coordinating-computing center on earth." This method, he says, allows measurements to be made along the most interesting parts of the interplanetary station's orbit, and he adds that the signal is given on the same frequency as that used by the station's transmitter.

Continuing his discussion of the importance of computing technology in the U.S.S.R. conquest of space, Siforov mentions that data on the hidden part of the moon are being transmitted on a wavelength of 7.5 m. and that information on cosmic rays will be translated into current and voltage. He predicts that the day is near when rockets will bring satellite stations to an altitude of 40,000 km. for TV relay. As for the future spaceship pilot—according to Siforov, he will be in effect a passenger since both speed and direction will be electronically selected and controlled. However, he says that landing of an automatic, radio-controlled rocket on the moon, as well as launchings of artificial moon satellites for survey purposes, will precede man's first interplanetary travel.

Water-Filled Cabins for Space Travel?

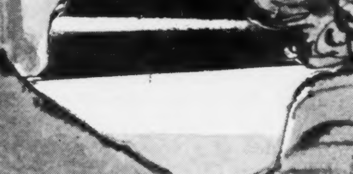
◆ With all the hubbub about training and conditioning of astronaut candidates, it looks as though the popular sport of skin diving might yet prove to be the best preparation for the role of space explorer. Both the United States and the Soviet Union have been investigating the possibility of immersing the astronaut in water to protect him from the hazards of space voyages.

According to a September issue of *Soviet Aviation*, the idea originated with no less a personage than the renowned aviation pioneer Tsiolkovskiy. As recounted in the item, Tsiolkovskiy was experimenting with a sealed tin can filled with water and an egg suspended in it because of the water's salinity. When the can was dropped from the third floor of a building, the egg remained unbroken. Thus the idea of a space cabin filled with water was born.

The *Soviet Aviation* item theorizes that a man with an aqualung placed in such a cabin would be able to survive great acceleration overload. It further states that a comparative study of conditions under which skin divers and fliers in water-filled cabins have to work has already shown that the idea is sound.

Millionth-Gram Accuracy Claimed for Czech Balance

◆ At the international industrial exposition held in Brno, Czechoslovakia, in September, 1959, a unique balance was exhibited which weighs minute portions of substances, reputedly with an accuracy of one-millionth of a gram. A special projection meter shows the amount of material on the balance, the bulk of which is sometimes so small that it cannot be seen with the naked eye. The sensitive device is the product of the Meopta plant in Brno.



New package for tomorrow's jet power!

Greater jet thrust, faster climb, longer range, and more operating efficiency . . . at lower sound level. That's the story of tomorrow's new jet engines now in production. Rohr's role is the production of complete, ready-to-install jet pods to house these mighty engines. Such complex units are but one of the many major aircraft assemblies built by Rohr — the world's largest producer of components for flight.

ROHR
AIRCRAFT CORPORATION

Shown above is the famous Boeing 707 — soon to fly with the new Pratt & Whitney JT3D-1 turbo fan jet engines.

World's largest producer of components for flight • Main plant and headquarters: Chula Vista, Calif. • Plant: Riverside, Calif. • Assembly plants: Winder, Ga., Auburn, Wash.

Editorial

What Price Originality?

Sponsored by the National Science Foundation, housed and entertained by the Worcester Polytechnic Institute, some 45 representatives of educational institutions, industry, and the technical societies sat down (December 3, 4) to contemplate "Research Goals" in general and to consider specifically: "How can young research scientists and engineers be brought more stimulatively, imaginatively, and creatively into contact with the frontiers of science and technology." To put some fences around the discussions, attention was generally directed toward two questions: (a) "How can Colleges and Universities encourage originality in Research Goals?," and (b) "How can the Scientific and Engineering Societies Promote Originality?"

Because the conferees came largely from educational institutions, the first of the two topics came in for major attention. After two days of discussion (and some nightwork by a committee of experts) a set of resolutions was drafted which, in outline, recommended that (a) colleges and universities encourage "creative thinking" among their students by presenting them with "challenging problems"; (b) the "promising" student be brought into contact with "great minds" in his chosen field; (c) "originality" be stressed in postgraduate programs; and (d) universities provide "an atmosphere and an environment" conducive to attracting good teachers.

In all innocence we supposed that such notions were long since recognized as fundamental in educational circles. We were more hopeful that some novel suggestions might be forthcoming regarding the role of the technical societies. After due deliberation, however, the final recommendations which evolved in this area could be summed up as follows: (a) technical societies should establish practices and procedures (supplementing normal Student Branch activities) to bring talented young researchers into informal contact with the leaders in their profession; (b) they should encourage presentation of papers on "forward-looking" research and development topics, reducing their attention to discussions of topics "in the past tense"; (c) discussion of matters pertaining to related disciplines should be fostered, even if such discussions cut across areas normally treated by other societies; (d) societies should establish "forums" for short, informal, preliminary discussions of new ideas (not necessarily complete or in final form for publication) to promote more rapid interchange of new thinking; (e) scientific and technical societies should exchange ideas along the "Frontiers of Science"; and (f) attendance at meetings by young engineers should be encouraged.

With these conclusions few could find grounds for disagreement. Such things seem implicit in the normal objectives of a modern technical society. They contain no novel or controversial elements, but we see no particular harm in restating them.

There was one aspect of the common problem which (we thought) merited some discussion, but which was touched upon very lightly by the Conference. This concerns the motivation of students entering research fields and the general reluctance of young engineers to "stick out their necks"—to risk "originality."

Research work in any area can be significant only if the people who do it believe thoroughly in what they are doing. Research goals high enough to be worth while can be attained only by dedicated men with innate personal curiosity who seek truth for its own sake, regardless of consequences. Such motivation seems to us to be dangerously lacking in most young engineers today. Many who are engaged in scientific or technical work seem so indoctrinated with Togetherness and Groupthink that they have lost the urge to strike out and do any creative thinking on their own. They seem to be so interested in "personal security" and in living "the good life" which eager industrial recruiters have promised them that distant research goals tend to fade and become less important than considerations of "what is there in it for me." They appear to believe that "recognition" of their "professional standing" derives mainly from membership in a group. It seldom seems to occur to them that they have an obligation to contribute to the stature of the group by breaking away from the herd, by doing something original on their own. The urge to be "different" seems to be on the decline.

By the time young people get into college or join professional societies, it is already too late to expect them to switch to "creative thinking." The problem must be attacked at a level much lower on the academic scale. If we are to have any chance of reaching whatever research goals we select as desirable, the promising student must be identified early in life and conditioned to seek answers for himself rather than rest content to be "spoon fed."

If we are to meet successfully the kind of technological competition put up by the protagonists of planned economies and police states, we cannot look to our universities and our technical societies to make up for the deficiencies of our basic educational system. Creativity cannot be "injected" at the top. We must somehow find teachers at the primary and secondary school levels who can recognize the potentially creative thinker and who will then take enough individual interest in him to develop his capabilities. We must very early break down the herd instinct—the urge for protective "togetherness"—which seems to be a by-product of our present social and cultural environment. Originality must be encouraged, not suppressed. We must persuade the promising student of the intrinsic worth of the search for truth, regardless of personal sacrifice. Such are the problems that must be solved, the questions that must be answered before any but the most modest research goals can be attained. It is to be regretted that the Conference spent so little time in these areas. S.P.J.

IAS...

President—1959

WILLIAM LITTLEWOOD, HFIAS

Vice-President—Equipment Research

American Airlines, Inc.

As 27th President of the IAS, William Littlewood accomplished the many and varied duties normally associated with professional society leadership with rare ability and thoroughness. And he carried them out with an enthusiasm so overflowing it splashed onto all those who were privileged to work with him during the year.

"Bill Littlewood's Year," of course, has a little while to run at this writing. But it can be said, early and without qualification, that he has been the Institute's "most traveling-est" Chief Executive. (Consistent with this distinction, the accompanying photo showing Mr. Littlewood in action is published rather than the conventional portrait study. It was taken at the recent National Midwestern Meeting in Wichita with retiring Boeing Vice-President J. Earl Schaefer.)

While statistics in the full make dull reading, it is safe to say that President Littlewood logged thousands of air-travel miles to IAS areas—visiting with Sections and, frequently, appearing as their guest speaker. His topics ranged from air transportation problems in the jet age to the many and rapidly changing aspects of aerospace technology. He launched the Institute's Connecticut Section (35th and newest) on its career in November.

President Littlewood attended all nine National and Regional meetings during the year. He was a most constant host for the 12-day Seventh Anglo-American Aeronautical Conference. Earlier in his term he appeared at four of the Regional Student Conferences.

President Littlewood's devotion to the Institute and its Sections, and his unstinting attention to the professional needs of its members, has earned for him the sincere gratitude of those whom he has served so well.

President—1960

DONALD L. PUTT, FIAS

President

United Research Corporation of Menlo Park

The election of Donald L. Putt brings to the Institute's highest office a former Lieutenant General whose 30-year career was climaxed by an appointment as Deputy Chief of Staff for Development, and Military Director of the Scientific Advisory Board to the Chief of Staff, USAF. Formerly, he was Commander, ARDC.

General Putt's wealth of experience in research and development was accumulated following many exclusively military assignments as pilot in the 30's. On graduation from C.I.T. late in that decade, he held several engineering positions. His promotions thereafter all were advancements in the R&D areas of the Air Force.

On retirement from military service in 1958, General Putt became an assistant to Dr. Theodore von Kármán, Director of the National Academy of Science (ARDC summer study group for the Air Force). He became President of United Research Corp. of Menlo Park, doing research and development in missiles and space technology, in October, 1958.*

General Putt takes over the IAS presidency at an important and critical point in our history.

Implementation of the reorganization program, agreed upon by the Council and approved by the membership in 1959, will be the main concern of the new President. In this, of course, he will have full support from the regional vice-presidents and Council members.

We are indeed fortunate in having the benefit of his long experience as an organizer and coordinator at this time.

The entire staff of the Institute pledges to him its full and unqualified cooperation as he carries out the mandates of the Council and the membership.

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* General Putt's complete biography may be found on page 13 of this issue.—Ed.

"In Part I the high-thrust nuclear system is discussed in the performance of the Martian mission, while Part II will be devoted to the low-thrust electrical system. Part II will also include a review comparison of the high- and low-thrust systems."

Manned Nuclear Space Systems

Part I—High-Thrust Nuclear Systems

E. B. Konecci, R. F. Trapp, and M. W. Hunter, AFIAS
Douglas Aircraft Company, Inc.

In order to achieve interplanetary flight with large payloads, nuclear reactors will be used as heat sources for high-thrust rockets and/or electrical propulsion. The feasibility of manned nuclear systems was pointed out in an earlier study[1] which concluded that

(1) The nuclear reactor is the prime radiation source. If shields are maintained in place while exiting through the Van Allen radiation belts, the dose, if any, received from the belts will be small relative to the scattered and direct radiation doses from the reactor.

(2) Calculations indicate that optimal nuclear spaceship design need not compromise the crew.

(3) The problem of relative biological effectiveness (RBE) for incident neutrons can be simplified by the use of the H_2-B^{10} combination to convert the neutrons to gammas at the crew compartment.

(4) Operation through planetary atmospheres (Earth, Mars, Venus) will require scatter shielding for the crew.

(5) Direct shielding from propellant and other shield materials will provide attenuation for the direct radiation from operation and shutdown conditions.

The present paper is a more specific analysis than the previous work[1, 2] and is applied to a particular Martian mission. In Part I the high-thrust nuclear system is discussed in the performance of the Martian mission, while Part II will be devoted to the low-thrust electrical propulsion system. Part II will also include a review comparison of the high- and low-thrust systems.

Mission

A round-trip Martian journey has been chosen for this investigation of nuclear space systems. The manned nuclear vehicle will be launched from Earth through Earth's atmosphere. It will establish an orbit around Mars. The crew will perform reconnaissance and probe experiments from the nuclear vehicle in the Martian orbit and, if deemed advisable, will explore the surface of Mars with a small maneuverable chemical vehicle which would return to the nuclear vehicle in orbit. Then, from the Martian orbit, the nuclear vehicle would return to Earth, establishing an orbit around Earth, and, finally, the crew would land on the surface of Earth in a small entry vehicle.

The assumed mission could be performed, in the minimum energy case, in about 3 years' time with about 70,000 ft. per sec. impulsive velocity (including 4,000 fps drag and gravity allowance) by using Hohman transfer. A trip of about 1 year is obviously more desirable for manned travel but would require about 120,000

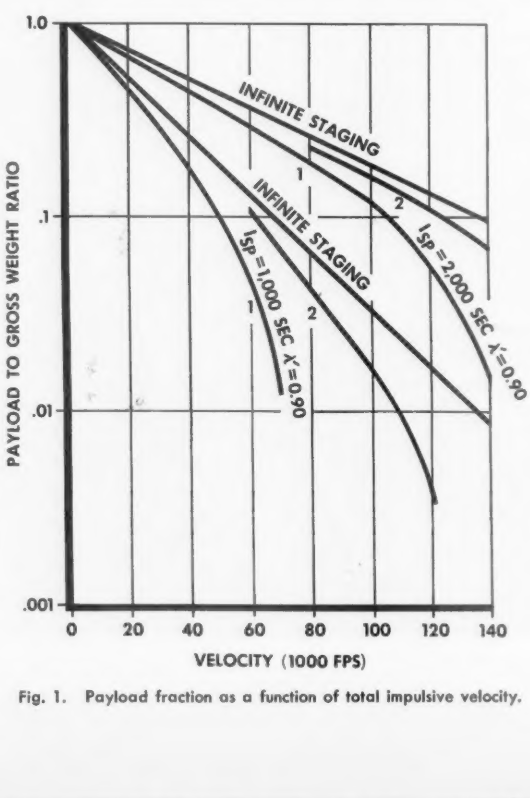

Fig. 1. Payload fraction as a function of total impulsive velocity.

fps. This velocity capability may be realized in several ways, the most desirable of which would be to have propulsion performance high enough so that a reasonable sized single-stage vehicle would suffice. For example, if a specific impulse I_{sp} of 2,000 sec. were attainable with a $\lambda' = 0.90$ (λ' is the ratio of fuel weight to total propulsion system weight), then the mission could be accomplished with a single-stage vehicle with gross weight W_0 to payload weight W_{pl} ratio $\Gamma = 16.5$.

A specific impulse of 2,000 sec. requires reactor design beyond the current state of the art, and it would be desirable to be able to perform the mission with $I_{sp} =$ 1,000 sec. If a hydrogen supply were available at Mars, it would be possible to refuel there and drastically reduce the performance requirements to an impulsive velocity of 68,000 fps. However, either a $\lambda' = 0.935$ or an $I_{sp} = 1{,}135$ sec. would still be required for the gross weight to payload ratio of 16.5. If, in addition, 8,000 fps of atmospheric braking could be used upon entry to the Mars orbit, then it would be possible to do the mission with the same gross weight to payload ratio of 16.5 with a $\lambda' = 0.90$ and $I_{sp} = 1{,}000$ sec.

Fig. 1 shows rocket payload fraction as a function of total impulsive velocity at λ' of 0.90 and I_{sp} of 1,000 and 2,000 sec.

Unfortunately, no hydrogen supply exists at Mars for refueling purposes. The establishment of a refueling station at Mars should be the prime objective of the first expeditions since its effect on the transport system would be so great. Meanwhile it is possible to perform the mission by dispatching tankers from Earth. These tankers would employ lower energy Earth-Mars transit paths to increase their payload. They would leave about 1 month earlier than the manned ship and arrive at Mars 2 weeks before the manned ship was ready to return. By this means, it is possible to launch the tankers and accurately monitor them from Earth for a month before the manned ship departs to be sure that they are all properly on course and will arrive at Mars on schedule. The last 2 weeks that the manned ship is at Mars then consist of the refueling operation, including the monitoring of the approach of the tankers and command control of the establishment of their orbit around Mars if this proves necessary.

This analysis shall assume the most conservative of the above concepts—that is, $I_{sp} = 1{,}000$ sec., $\lambda' =$ 0.90, and no atmospheric braking utilized. Under these assumptions, single-stage vehicles could be used, but their gross weight to payload ratios would be large. Hence it is assumed that both manned and tanker vehicles shall be of two stages. Fig. 2 shows a size comparison of the two-stage high-thrust nuclear-powered spaceship and the DC-8 Fig. 3 gives a profile view of the second-stage vehicle showing the configuration of the seven hydrogen tanks, the crew compartment, the shielded well, sustenance material, airlock, entry vehicle, and the reactor. The booster impulsive velocity is chosen as 30,000 fps in order to provide later comparison on launch of ionic systems into orbit. This also provides a fail-safe capability in case the second

Dr. Konecci is Head, Life Sciences, which includes responsibility for human factors and bioastronautics, in Missiles and Space Systems. He has attended Clemson College, Roosevelt University, University of Chicago, University of Berne (Switzerland), the Air Command and Staff School, and Oak Ridge Institute of Nuclear Studies. His Bachelor's degree was in biology and chemistry; the Doctoral degree in medical physiology was received *cum laude* from the University of Berne in 1950. While at the USAF School of Aviation Medicine, 1950–1955, he was a research scientist in the Departments of Space Medicine, Chief, Physiology-Biophysics & Toxicology Branch, Directorate of Flight Safety Research, Office of the Inspector General, Hq. USAF, until January, 1957, when he joined Douglas. He is a member of numerous scientific and professional societies and has authored more than 60 papers in the fields of physiology, radiobiology, flight safety, and human factors.

Mr. Trapp is a nuclear engineer in the Thermodynamics Section, Missiles and Space Systems Engineering Department. He obtained a B.S. degree in engineering physics from the University of Illinois in 1954. He has done graduate work in physics and nuclear engineering at the University of Illinois, Ohio State University, and the University of California at Los Angeles. He served in the USAF from 1954 to 1956 at WADC working on missiles and the aircraft nuclear propulsion program. Since 1956, he has been with Douglas working initially on aircraft nuclear propulsion and, since 1957, on nuclear rocket propulsion. Mr. Trapp is a member of the American Nuclear Society, and has authored several papers concerned with shielding for manned nuclear rockets.

Mr. Hunter is Assistant Chief Engineer, Space Systems. He received his A.B. degree in physics and mathematics from Washington and Jefferson College (Pennsylvania) in 1942 and the M.S. degree in aeronautical engineering from Massachusetts Institute of Technology in 1944. Mr. Hunter has been with Douglas (Santa Monica) since 1944—first as a member of the Aerodynamics Performance Group, then for 8 years in charge of the Missiles Aerodynamic Group, and later as Assistant Chief Project Engineer for Missiles. In early 1956, he became Chief Missiles Design Engineer and, in late 1958, Assistant Chief Engineer, Space Systems. Mr. Hunter is an Associate Fellow of the Institute of the Aeronautical Sciences and a member of the American Rocket Society; he is also a Phi Beta Kappa and Tau Beta Pi.

nuclear stage does not operate properly. The manned and tanker vehicles are identical except that the tanker carries propellant as payload. The chosen mission requirements are summarized in Table 1. Fig. 4 depicts the history of the journey.

Vehicle sizing has been accomplished using a payload weight of 55,000 lbs. as discussed later. The upper stage of the manned system will gross about 239,000 lbs. The two-stage take-off weight will be about 734,000 lbs.

Decreased energy requirements in addition to fuel-carrying capacity as payload enable three tankers yielding 88,000 lbs. of propellant each, to provide the 244,000 lbs. of propellant required for the return mission. The payload carried back to Earth is assumed to be 36,000 lbs. A fourth tanker would probably be sent on the Martian trip to supply system reliability.

The payload of the manned vehicle will be composed of three men, their life-support materials, shielding, equipment, structure, and a fueled chemical vehicle for Martian surface exploration. It may be possible to re-

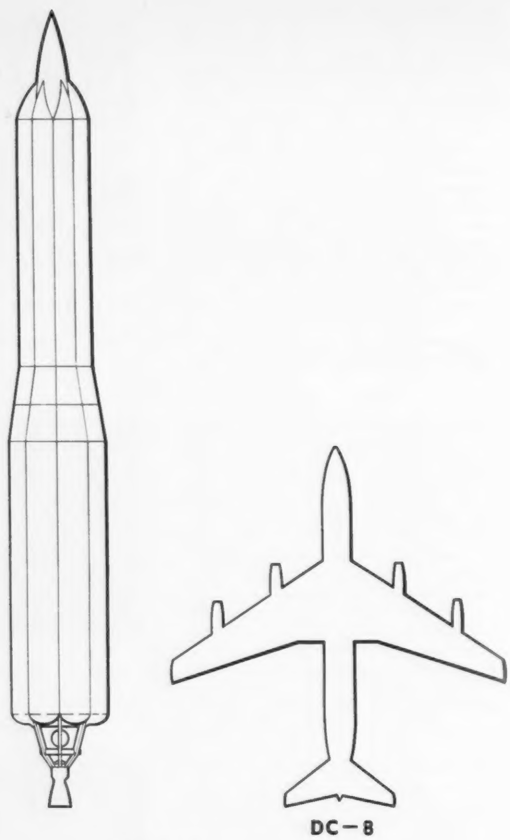

Fig. 2. Two-stage nuclear vehicle.

place tanks on the manned vehicle with those from tankers in case severe meteoroid damage has occurred. The tankers which remain stored in Martian orbit after the expedition, including the reactors, are a possible source of components for a Martian refueling station at a future date.

The chosen mission looks very attractive from a propulsion and time basis, but what about the radiobiological, life-support, and radiation shielding problems?

Radiobiological Aspects

"Radiation brings about a change in matter only by the virtue of energy that is actually absorbed in this matter. A biological effect can also depend on the type and energy of the radiation making possible the different biological effects from equal energy absorption."[2] Since it is convenient to measure exposure in purely physical terms, an additional factor is used to indicate the RBE of the different types of energy of radiation relative to X or gamma radiations which have an RBE of 1. The RBE for neutrons varies with their energy from 2 to more than 10. The unit of RBE dose is the rem (roentgen equivalent man). Rem is equal to RADS times RBE. (The RAD is the unit of absorbed energy—i.e., 100 ergs/g of any material.) In this study, since all the mixed radiations from the reactor have been converted to gamma rays by the time they have reached the crew compartment, the RBE is unity.

A discussion of the consequences of acute whole-body radiation can be found in the earlier paper.[1] The new Bureau of Standards *Handbook 69* (updates *Handbook 52*) lists the recommendations of the National Committee of Radiation Protection (NCRP) for meeting the principals established by the International Commission on Radiological Protection (ICRP).

Three basic changes in radiation protection philosophy are spelled out in the new recommendations:

(1) Acceptable dose rates are based on quarterly, rather than weekly, limits.

(2) Accumulated doses are limited by new age-dependent formulas.

(3) Dose limits are prescribed not only for radiation workers but also for whole populations and nonoccupational groups near nuclear installations.

The new calculations have been based on 50 years of continuous occupational exposure, rather than 70 years.

The recent Los Alamos *General Handbook for Radiation Monitoring*[3] summarizes the new changes in the following way: "The maximum permissible accumula-

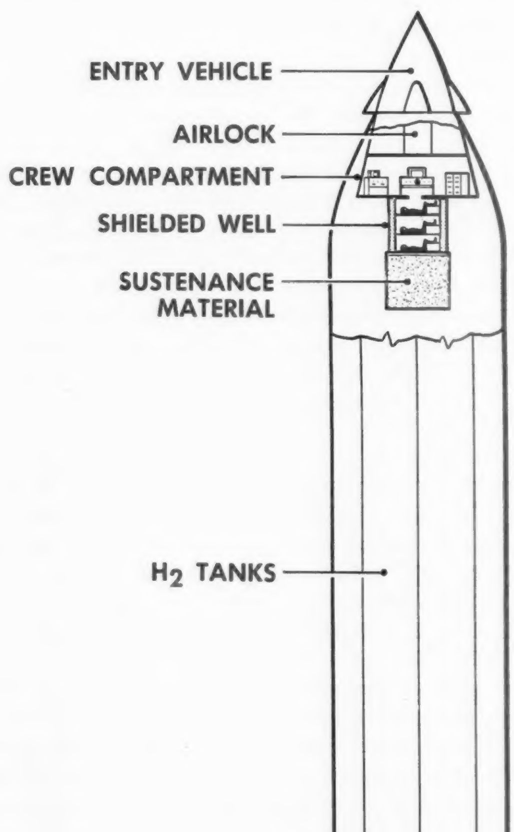

Fig. 3. Manned nuclear stage.

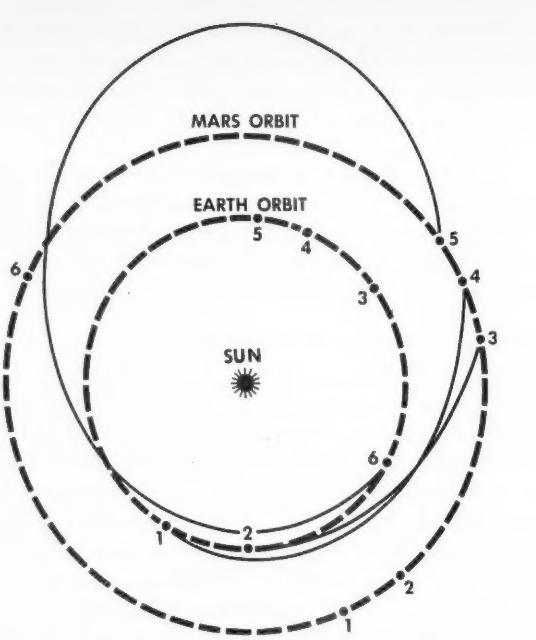

Fig. 4. History of Martian trip: (1) tanker vehicle leaves Earth, (2) manned vehicle leaves Earth, (3) manned vehicle arrives at Mars, (4) tanker vehicle arrives at Mars, (5) return vehicle leaves Mars, (6) return vehicle arrives on Earth.

tive full-body occupational dose in rem at any age greater than 18 is computed by MPD = 5 (N-18) where N is the age in years, provided no annual increment exceeds 12 rem. Not more than 1/4 of the 12 rem maximum permissible yearly dose (3) rem shall be taken in 1/4 of a year." The acceptable (administrative) yearly exposure at the Los Alamos Scientific Laboratory is 5 rem. The 12 rem maximum is used (1) only when the accumulated exposure after the age of 18 is documented; (2) then only in cases where judicious use of exposure has been made; and (3) where, in unique and unusual instances, after due consideration has been given, restrictions would result in serious impairment to the functions in the laboratory.

Table 2 summarizes the biologic response to ionizing radiation. Medical evidence on the ability of the human to sustain acute or short-term exposure, whole-body radiations appears to be reasonably clear.[1] Acute doses between 0 and 50 r are considered as subthreshold for the acute radiation syndrome and present no medical problems in an emergency situation. In the dose range, between 50 and 100 r, there will be trivial and transitory chronic changes, again imposing no medical problem. According to present knowledge, these mildly acute effects are followed by complete recovery and return to normal life. Therefore acute doses up to 100 r could be tolerated in emergency situations or if mission requirements dictated the necessity for taking such a dose. It is understood that the dose will be kept as low as possible since exposure to ionizing radiation, no matter how small, would result in some somatic and/or genetic damage to the astronauts.

Present available data lead one to the conclusion that the genetic harm from any ionizing radiation is proportional to the total dose—that is, the total accumulated dose to the reproductive cell from the conception of the parent to the conception of the child.[4] This implies that all radiation, whether received acutely or chronically, is genetically undesirable since it induces harmful mutations.

Genetic effects due to radiations in space flight—that is, from nuclear power plants, as well as radiation belts, solar flares, or cosmic rays—should not be overstressed for two reasons:

(1) The number of astronauts going into space within the next generation will be extremely small in comparison with the total population; hence, even if the mutated genes were passed on to their progeny, the effects would be limited to an extremely small number in the population.

(2) Genetic considerations in space flight do not apply if the irradiated individual does not have offspring after the period of exposure. This should be an important factor in crew selection for early nuclear space vehicle flights. In the early manned space explorations, it should be possible to utilize individuals who have completed their families and are near the age of 45 since highly trained, mature individuals who have not been exposed to high doses of radiation in their lifetime would be chosen for such missions. They would have been exposed only to natural radiation and some diagnostic X-rays.

In removing the genetic hazards, the radiation damage suffered by the astronauts would be somatic—e.g., shortening of life span, leukemia. The incidence of these and other effects (cataracts of the lens of the eye, aplastic anemia) in an irradiated population is proportional to the total radiation dose and their distribution is statistical in character. "Whereas 225 r of whole-body gamma radiation may shorten the average life expectancy of a large population by about 3–6 years, it cannot be said that the life of any specific individual in the population will be shortened by that amount."[5] Langham points out that radiation exposure limits

Table 1. Summary of Martian Mission Requirements

MISSION	PHASE	VELOCITY	TIME
TANKER			
EARTH LAUNCH	STAGE 1		
	(A) USEFUL IMPULSE	26,000 FPS	5.83 MIN
	(B) LOSSES	4,000 FPS	.90 MIN
	STAGE 2	13,000 FPS	2.49 MIN
TRANSIT			187 DAYS
MARS BRAKING	STAGE 2	13,000 FPS	2.49 MIN
MANNED			
EARTH LAUNCH	STAGE 1		
	(A) USEFUL IMPULSE	26,000 FPS	5.83 MIN
	(B) LOSSES	4,000 FPS	.90 MIN
	STAGE 2	14,500 FPS	2.37 MIN
TRANSIT			125 DAYS
MARS BRAKING	STAGE 2	23,500 FPS	3.85 MIN
MARS ORBIT	EXPLORATION		50 DAYS
	REFUEL		15 DAYS
MARS LAUNCH	SINGLE STAGE RETURN	18,500 FPS	2.79 MIN
TRANSIT			246 DAYS
EARTH BRAKING	SINGLE STAGE RETURN	34,500 FPS	5.83 MIN
TOTALS	MANNED	119,000 FPS	421 DAYS

Table 2. Biologic Response to Ionizing Radiation

DOSE (r)	DOSE RATE	EXPOSED AREA	BIOLOGIC RESPONSE	COMMENT
0.3	WEEKLY	TOTAL BODY	PROBABLY NONE	FORMER MAXIMUM PERMISSIBLE DOSE MPD GAVE 15 REM/YEAR
1.5	WEEKLY	EXTREMITY	PROBABLY NONE	MAXIMUM PERMISSIBLE HANDS, FOREARMS, FEET AND ANKLES
[illegible]	QUARTERLY	TOTAL BODY	PROBABLY NONE	MPD QUARTER YEAR DOSE
5	YEARLY	TOTAL BODY	PROBABLY NONE	ADMINISTRATIVE LASL* YEARLY EXPOSURE
12	YEARLY	TOTAL BODY	PROBABLY NONE	MPD YEARLY DOSE
25	SINGLE DOSE	TOTAL BODY	RECOGNIZABLE BLOOD CHANGES	ACCEPTABLE EMERGENCY DOSE
30-50	ACCUMULATED	TOTAL BODY	GENETIC DOUBLING DOSE	ESTIMATED DOUBLE THE NATURAL MUTATION RATE
50	5r/YEAR	TOTAL BODY	PROBABLY NONE	PERMISSIBLE EXPOSURE TO AGE 30
75	YEARLY	EXTREMITIES	PROBABLY NONE	MPD PER YEAR
150-200	SINGLE DOSE	TOTAL BODY	ACUTE RADIATION SYNDROME	BECOMES NOTICEABLE IN THE MAJORITY EXPOSED
225	5r/YEAR	TOTAL BODY	PROBABLY NONE	POSSIBLE ACCUMULATED 50 YEAR OCCUPATIONAL DOSE OR MPD LIFE TIME EXPOSURE
300-500	SINGLE DOSE	TOTAL BODY	LD_{50}	50% LETHALITY
300-600	SINGLE DOSE	OVARIES	STERILIZATION	
400-500	10-50 r/DAY	TOTAL BODY	ACUTE RADIATION SYNDROME	CLINICAL RECOVERY
600-800	SINGLE DOSE	TESTES	STERILIZATION	
5000	SINGLE DOSE	TOTAL BODY	INCAPACITATION	ACUTE INCAPACITATING DOSE
5 (N-18)	ACCUMULATED	TOTAL BODY	PROBABLY NONE	ACCUMULATED MPD AFTER AGE 18 NOT TO EXCEED 12 REM/YR

*LASL = LOS ALAMOS SCIENTIFIC LAB

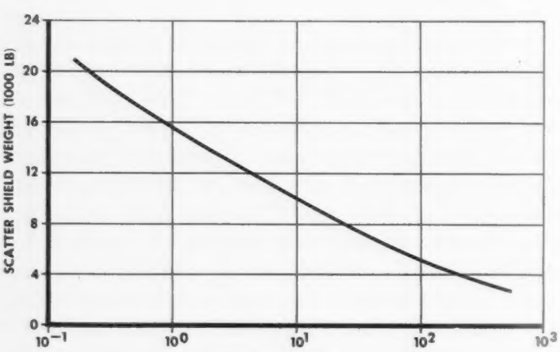

Fig. 5. Crew compartment scatter shield.

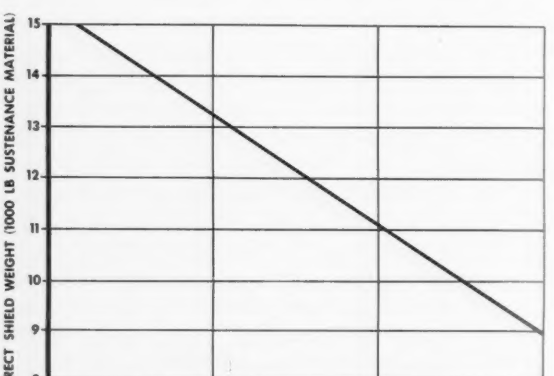

Fig. 6. Crew compartment direct shield.

should be set realistically in early phases of manned space flight since the maximum permissible exposure levels set by the national and international commissions for radiological protection are very conservative and seem unrealistically conservative.

In view of the multiple hazards[6] other than radiation to be faced by the astronauts, a somatic effect like possible shortening of life span by a few years should not be considered too great a price to pay for the accomplishment of a successful mission.

Radiation Environment and Shielding

To provide radiological protection to the space crew, shields must be applied to the nuclear vehicle. Independent scatter and direct shields were determined for the crew compartment of a nuclear space vehicle based on the radiation environment. In determining this environment, leakage of fast neutrons, thermal neutrons, and three energy groups of gamma radiations were made and assumed to be proportional to reactor power. The leakage radiations, which amounted to about 0.6 per cent of the reactor power, were considered to be emitted isotropically. The direct radiation environment was then determined, being proportional to reactor power and inversely proportional to the square of the reactor-crew compartment separation distance, assuming the reactor to be a point source. The thermal neutrons leaving the reactor were absorbed in a thin layer of B^{10} releasing a low-energy gamma to be added to the source gammas. This absorption process avoids consideration of the n, γ reaction in the nitrogen in the air.

The scattering of the three energy groups of gamma radiation in air was handled using Klein-Nishina scattering cross sections and summing the contributions to the dose rate at the crew compartment from all space. Variation of atmospheric density with flight time was included. The fast neutrons were scattered isotropically in the air. All neutrons incident upon the crew compartment were thermalized by passage through liquid hydrogen fuel and then absorbed in B^{10}. This absorption produces a distributed source of isotropic gamma radiation which was added to the incident scattered gammas. The unshielded radiation environment was thus determined.

Uranium shielding was sculptured about the crew compartment to yield the smallest scatter shield weight for each integrated dose. Direct shielding requirements of constant thickness were determined for the compartment base after consideration of propellant attenuation and its variation with time. Figs. 5 and 6 present shield weight, gross weight, and integrated dose data which can be used in system sizing. Fig. 5 indicates the combination of these variables for scatter shield weights applied to the mission under consideration. Fig. 6 shows the direct shield weights (here taken to include the weight of a shadow shield above the reactor used to decrease fuel boil-off) and the direct radiation integrated dose from operation and shutdown conditions.

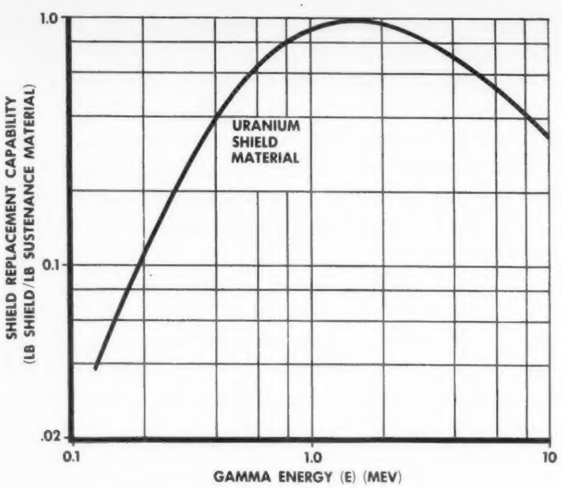

Fig. 7. Capability of crew sustenance material to replace various shields

An additional shielding concept[2] is the utilization of the required sustenance materials to replace shielding material—i.e., the dual utilization of food. Fig. 7 indicates the number of pounds of uranium replaced by one pound of sustenance material as a function of gamma ray energy. It is important to note that the shielding analysis above has reduced the shielding calculation to the attenuation of only gammas. It is quite apparent from Fig. 7 that the sustenance materials are most economically used in replacing high-energy radiation shields—i.e., the direct shield.

Manned Vehicle Payload

In order to accomplish the 421-day Martian mission, a minimum three-man crew is required and the manned nuclear vehicle will have to contain an adequate life support system.[7] Logically, on such a long journey, one would expect to strive for a completely regenerative ecological system in order to save payload weight. However, an evaluation of the problem indicates that the three-man crew should use a nonregenerative ecological system because the vital payload assumes the dual role of sustenance and direct shield material.[2,7] In addition, from a safety and reliability point of view, it is more desirable to take the vital payload in the form of a nonregenerative system.

The shielding capability of the sustenance material does not change with time since the human waste products replace the metabolized materials. The average man (normal activity, 3,000 kilocalories) requires 12.2 lbs./day of vital payload—i.e., 2 lbs. of oxygen, 2.5 lbs. CO_2 absorber (LiOH), 2 lbs. food, and 5.7 lbs. water. A safety factor increases this figure to 15 lbs./man/day. This means that the three-man crew would have 45 lbs./day or about 19,000 lbs. of sustenance. At 0.8 replacement capability for the direct shield (see Fig. 7), the 19,000 lbs. of sustenance material would be equivalent to 15,200 lbs. of uranium shield material.

Table 3 gives the distribution of the 55,000-lb. payload on the manned nuclear vehicle. The Mars reconnaissance and Earth entry vehicle gives the crew the capability of an aerodynamic landing on the Martian surface and a return to the Mars nuclear vehicle orbit. It is anticipated that only one crew member would land on Mars. If the landing, take-off, or rendezvous of the reconnaissance capsule was unsuccessful, the two crew members in the nuclear vehicle (in the Martian orbit) could still return to Earth and be picked up in Earth orbit by a shuttle vehicle.

The 14,000 lbs. of U^{238} shield would permit the crew to receive a scatter dose of about only 2 rem. The scatter shield could be dropped from the vehicle after exit through the Earth's atmosphere, thereby reducing energy requirements. However, it is anticipated that the scatter shielding will be carried on the complete mission for several reasons. It will (1) aid in passing through the Van Allen radiation belts, (2) considerably decrease the hazard from other space radiation, (3) help protect the crew from tanker radiations during the refueling operation. It is assumed that there would be an advanced display with some controls in the shielded well.

For 386 days of the mission, the crew is protected against the direct radiations from the shutdown reactor by hydrogen fuel and sustenance material. It is only after the hydrogen is used up in establishing the Martian orbit and the Earth orbit on the return flight that the crew is subjected to direct radiations. The sustenance material being utilized as the direct shield significantly reduces the exposure to the shutdown radiations so that the crew would receive less than 10 rem direct radiation for the mission.

The space cabin contains the shielded well described in the earlier study.[1] The base of the well is 3 ft. by 6 ft. The direct dose for the different weights of sustenance material in Fig. 6 was calculated on this area of 18

Table 3. Distribution of Nuclear Vehicle Payload Weight

ITEM	WT IN LBS
SUSTENANCE MATERIAL FOR A 3 MAN CREW AT 15/LB/MAN/DAY (O_2, LiOH, FOOD AND WATER)	19,000
3 MEN PLUS PERSONAL EQUIPMENT	800
ALL OTHER EQUIPMENT (COMMUNICATIONS, ENVIRONMENTAL CONTROL, NAVIGATION, VEHICLE CONTROL, PROBES, ETC.	4,200
MAIN SEALED CABIN AND ACCESSORIES (e.g. AIR LOCK)	1,000
SAFETY FACTOR, (ADDITIONAL STRUCTURE AND EQUIPMENT)	1,000
MARS RECONNAISSANCE AND EARTH RE-ENTRY CAPSULE (VEHICLE)	4,000
FUEL ($H_2 + O_2$ AT I_{SP} 400 SEC) FOR CAPSULE	11,000
U^{238} SCATTER SHIELD	14,000
TOTAL PAYLOAD WEIGHT	55,000

sq.ft. An overlap of U^{238} scatter shield at the base of the well is equivalent to about 5,000 lbs. of sustenance shield, and 8,000 lbs. of actual sustenance material reduces the direct dose to 1.25 rem directly above this well. This leaves 11,000 lbs. of sustenance to be used to increase the direct shield area under the crew compartment. The 11,000 lbs. spread over another 18 sq.ft. would give a direct shielded area of almost 7 ft. in diameter. The direct dose above the lesser shielded area would be 11 rem if the crew spent all their time above it. In the actual operation, the procedure would call for the crew to remain in or directly above the well for the first day after reactor shutdown. After the first day, two thirds of the shutdown radiations will have passed. Therefore the direct dose above the lesser shield area from a day after shutdown to the refueling with hydrogen from the tankers in the Martian orbit would be a maximum of only 3.7 rem. A lesser direct dose would be expected after establishing the Earth orbit since the crew would attempt to enter and land on Earth a day or so after arrival. During the Martian orbit, which lasts for approximately 50 days, the crew would be expected to spend about 35 days of this time above the 7-ft.-diameter direct shielded area. The utilization of the remaining part of the crew compartment, some 17 ft. in diameter, would be limited to short periods of time so that the crew would not receive significant increases in direct radiations.

On return to Earth, the vehicle payload will be reduced to 36,000 lbs. because of the utilization of 11,000 lbs. of chemical fuel and the discard of about 8,000 lbs. of waste material after refueling. This loss of equivalent shield material will not handicap the astronauts since fuel will provide shielding until Earth orbital condition is achieved, at which time the crew will proceed with Earth entry.

Discussion

An analysis of the chosen nuclear mission to Mars leads to several general conclusions. A three-man Martian expedition with a 55,000-lb. payload is feasible using two-stage nuclear vehicles with an I_{sp} of 1,000 sec. and a λ' of 0.90. Three nuclear tankers would be required to carry sufficient hydrogen fuel for the manned nuclear vehicle to return from the Martian orbit. The tankers would depart from Earth ahead of the manned vehicle on a lower energy orbit.

The total exposure to both direct and scatter radiations for the 14-month mission has been kept to less than 12 rem—i.e., the new maximum permissible dose for 1 year. With 14,000 lbs. of U^{238} scatter shield, the three-man crew would be exposed to about 2 rem of scatter radiation on exit through the Earth's atmosphere. The scatter shield would remain in place for the entire mission and could be effectively utilized to decrease the exposure from other space radiations. For 386 days of the mission, the crew would be protected from the direct (operating and shutdown) radiations by a combination of hydrogen fuel and/or sustenance material. The sustenance material would provide direct shielding for the remaining 35 days of the mission.

The crew would have the capability of exploring the surface of Mars with a small maneuverable vehicle if, after performing reconnaissance and probe experiments, such a venture would be deemed advisable. This vehicle would carry sufficient fuel and oxidizer to enter the Martian atmosphere, aerodynamically land, and return to the Martian orbit. The chemical vehicle would also be utilized as the Earth entry capsule. If this vehicle was damaged or lost during the Martian surface exploration, which would be carried out by one crew member, then the nuclear vehicle with the other two crew members would still have a capability of returning to Earth, establishing an orbit. The two crew members would be retrieved by a shuttle vehicle.

The greatest exposure to the astronauts would be received from the direct radiations after the hydrogen fuel has been utilized to establish the Martian orbit. This imposes certain restrictions on the movement of the crew within the crew compartment since an area of only 7 ft. in diameter is adequately shielded. The remaining parts of the compartment could be manned for limited intervals. This is not considered a serious design problem since instrumentation and various types of equipment could be stored and operated around the periphery of the crew compartment. It would also be possible to design an elongated space cabin 7 ft. in diameter which would have adequate shielding and volume. In the particular configuration chosen, the airlock above the crew compartment joining the cabin with the chemical vehicle would be protected by the shadow shield at the base of the crew compartment, enabling the crew to have access to that vehicle.

If for one reason or another the crew was required to extend their flight time, the safety factor in the vital payload would give another 103 days under normal activity (3,000 kcal. metabolism). In other words, at 12.2 lbs./man/day, the 19,000 lbs. of sustenance material would last 524 days. If survival was dependent on extending this time still further, the astronauts could initiate a programed reduction in metabolism and significantly extend their flight time capability. In the basal metabolic state, which is 1,760 kcal. for the average male, the sustenance requirement would be 7.3 lbs./man/day—i.e., 1.2 lbs. O_2, 1.5 lbs. CO_2 absorber, 3.4 lbs. H_2O, and 1.2 lbs. of dry food. Since some activity above basal metabolism, like 2,100–2,200 kcal., would be required, then about 8.7 lbs. of sustenance/man/day would be needed. If after 125 days of normal activity the astronauts were compelled to change course extending their flight time beyond the 421-day mission, then 4,500 lbs. of sustenance would have been utilized. At this point, reduction of metabolism to the 8.7 lbs./man/day rate would permit over 550 more days of flight time. In other words, under these conditions the total mission time could be extended to over 675 days.

The equipment portion of the payload is restricted to 4,200 lbs. which would include all the communications devices; environmental, navigational, and vehicular control devices; measuring devices; recorders; Mars probes; etc. Since the mission is predicated on the basis of minimum human exposure, then undoubtedly the types of experiments and equipment required would be limited. For this type of mission the crew could be expected to take a larger dose than the 12 rem MPD per year. There is a capability, therefore, of reducing the weight of the sustenance material and the scatter shield, utilizing this for an increased equipment payload. The sustenance material could be reduced by several thousand pounds if we go from a nonregenerative to a partially regenerative ecological system. It is possible to recycle water—i.e., respiration, perspiration, and urine—by purifying the waste water. In addition, the chemical used to absorb CO_2 could be regenerated.

The chosen mission was based on a minimum crew of three astronauts. Since the analysis shows that the three-man crew would receive a total mission dose of about only 12 rem, there is a possibility of increasing the crew size without increasing the payload weight by permitting a greater exposure. Increasing the crew size to six would require the 14,000 lbs. of scatter shield to be sculptured over a shielded well twice the volume of the present three-man well. This would be about equivalent to reducing the present U^{238} shield to 8,000 lbs., permitting a scatter dose of 25 rem on exit through the atmosphere. The weight of the additional three men and their personal equipment would subtract 800 lbs. from the sustenance material, leaving 18,200 lbs. for direct shield purposes. A partially regenerative ecological system (purification and recycling of waste water) would allow the six-man crew to complete the mission on 18,200 lbs. of sustenance. The water would be replaced by additional oxygen, CO_2 absorber, and dry food. The six-man crew would require about 16,500 lbs. of vital payload (6.5 lbs./man/day = 2 lbs. O_2 + 2.5 lbs. CO_2 absorber + 2 lbs. dry food) for the 421-day mission. The remaining 1,700 lbs. would include the water purification system and a safety factor.

Part II, to be published in February, will discuss electrical propulsion, compare the high- and low-thrust systems, and present general conclusions on manned nuclear space systems.

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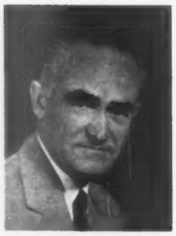
New escape capsules for Convair B-58 supersonic bombers eliminate restrictions of conventional escape systems. Ejection, which can be performed at all flight speeds and altitudes, is independent of pre-ejection system functioning.

Design Features of the B-58 Escape Capsule

Robert M. Stanley, FIAS
Stanley Aviation Corporation



Mr. Stanley is a Fellow of the Institute and President of Stanley Aviation, which he founded in 1948. He began his aeronautical career with Douglas in 1931 and 4 years later received a B.S. degree in A.E. from C.I.T. His experiences have included those of Navy pilot, engineer, and pilot with United Aircraft and have brought him international fame as a sailplane designer and pilot. He joined Bell Aircraft in 1940 as Chief Test Pilot, subsequently becoming Chief Engineer, then Vice-President—Engineering. In the latter post, he was responsible for much of the success of the X-1. In addition, he conceived the aerial launching technique that remains in use to improve safety and performance of supersonic research vehicles.

TRAVEL BY MAN in the earth's atmosphere and beyond presents the vehicle designer with a requirement for returning the crew safely to the earth's surface, even when the vehicle has to be abandoned in flight. In the early days of aviation, the pilot simply "went over the side" and opened his parachute. As sonic speeds were approached by turbojet aircraft, the ejection seat was developed to permit rapid and safe escape. However, as military aircraft began to operate consistently at altitudes above 40,000 ft., the crew had to be equipped with partial or full pressure suits to assure survival in case of ejection or cabin pressurization failure at high altitudes. With the possibility of extremely high-speed ejections, prevention of damage to these suits and loss of their helmets became a real problem. Similarly, limb flailing in such ejections has injury potential that makes leg and arm restraint devices a necessity in seats claiming supersonic escape capability. The result has been the development of a series of personal equipment and ejection systems that have high probability of success in emergency use, but which reduce the user's ability to perform his normal duties.

In order to progress beyond the escape and survival capabilities of the supersonic ejection seat and related equipment yet minimize their interference with normal cockpit activities, an entirely new approach to escape system design was required. Recognizing this need for the world's first supersonic bomber, the USAF's B-58 Hustler, engineers of Convair, A Division of General Dynamics Corporation, established specifications that have resulted in the escape capsule configuration shown in Fig. 1. Under development by the Stanley Aviation Corporation for Convair, there will be one of these capsules for each crew member in the B-58, since the units are designed to fit into the existing ejection seat envelopes.

These capsules make "shirtsleeve" flight in combat airplanes a reality again for the first time in 15 years because the necessity for wearing and carrying uncomfortable, restrictive protective gear is eliminated. The seat encapsulation and automatic pressurization features, the inherent protection from wind blast effects, and the provisions for landing in the capsule contribute most to this result. However, the built-in characteristics of the capsule as a container for a large amount of survival equipment and as a life raft are also major aids in removing equipment from the man.

As a result of statistical analyses of jet aircraft ejections, the critical nature of low-altitude ejections has long been recognized. Therefore, the B-58 escape capsules have been designed also to provide capability for saving the pilot and crew at low altitudes and low speeds. Acceleration loads upon ejection at high or low speeds and upon impact with the ground or water will be within human tolerance limits.

Pre-Ejection Operations

The functions which the escape capsule performs can be grouped conveniently into three phases: pre-ejection, ejection, and landing and survival. The pre-ejection operations consist of simultaneous leg and torso positioning, encapsulation by means of door closure, and pressurization of the capsule—all of which is accomplished by means of the system schematically represented in Figs. 2 and 3.

Two handles are provided, one on each side of the capsule seat, to initiate the pre-ejection system operation. Either or both of the handles can be used to start the sequence by firing a gas generator. The gases from this are routed to the torso-retracting inertia

Fig. 1. B–58 escape capsule.

reel and leg positioning mechanism. The occupant is drawn back against the seat with his head in the headrest when the reel winds in the special B-58 capsule restraint harness—a universal, nonadjustable configuration designed to position properly the torsos of both large and small men. Simultaneously, leg positioning is accomplished by mechanical devices powered by two thrusters. A bar beneath the occupant's thigh near the knee raises the legs in conjunction with a portion of the seat pan which is raised at the same time. In sequence with these, the lower legs are jack-knifed and restrained by means of cushioned bars that position the ankles.

When the leg thrusters have completed their stroke, the gas from the generator is permitted to flow to the door uplock release and door closure thruster. This causes the three doors to be unlatched and rotated downward to form a pressure-tight compartment around the occupant; rubber and rubber-impregnated cloth is used to seal the doors. Each capsule has a window in the middle door to permit the occupant to see the instrument panels and cockpit area directly in front of the capsule.

Door closure trips the capsule pressurization system on-off valve. If the aircraft air supply pressure is above 300 psi, the capsule pressurization system will utilize this source to pressurize the capsule to a pressure equivalent to 16,000 ft. (assuming cabin altitude has been higher). However, if the aircraft air supply is below 300 psi, a source-selector valve automatically switches to use pressurized air from a high-pressure bottle in the capsule. The capsule occupant is informed by means of a signal light whenever this capsule air supply is being used in order to warn him that only a limited time remains for capsule pressurization. The system is capable of pressurizing the capsule for a minimum of 10 min., utilizing both airplane and capsule air supplies.

Even after the capsule pressurization air bottle is depleted, the pilot can elect to fly at any altitude up to 42,000 ft. since each capsule contains an oxygen system in addition to its pressurization system. The former is designed to operate either from the airplane's oxygen supply or from a self-contained bottle. A small diluter demand regulator is used together with a standard pressure demand oxygen mask.

Door closure also trips switches in several electrical circuits. An "alert" circuit is energized upon closure of the pilot's capsule doors to signal the other crew members that their capsules should be closed. Another circuit arms the aircraft communication system for transmittal of "Mayday" calls.

After encapsulation, the pilot is still able to fly the airplane since the control stick is inside the capsule and the essential flight instruments are visible. Thus, the airplane can be flown to an altitude where the capsule can be opened if the pilot decides on such a course of action. If the capsule is thus returned to its normal open configuration, raising the pre-ejection control handles from the full down position a second time will result in performance of another complete pre-ejection cycle, using a second gas generator. Thus, should an emergency develop after the airplane has been flown down to safe altitude for unpressurized flight and the capsules opened, the crew still can be positioned and encapsulated again prior to ejection. Parenthetically, satisfaction of this requirement for repetitive performance has been a challenging design task.

The pre-ejection sequence from the time the handles are raised to the point where the doors lock closed takes from 0.5 to 1.0 sec. Pressurization from maximum altitude to 16,000 ft. takes an additional 2 to 3 sec.

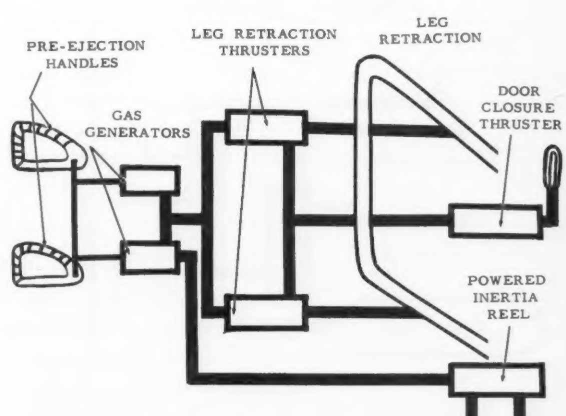


Fig. 2. Pre-ejection system schematic.

Capsule Ejection

As soon as the pre-ejection handles are pulled upward, the ejection triggers are exposed. The ejection system is dependent upon no other portion of the pre-ejection system. Thus, ejection can be accomplished even if the pre-ejection system malfunctions or the pre-ejection operations have not been completed. The limiting factor in speed of ejection is only the human being's ability to pull the handles and squeeze the triggers.

Initiators fired by trigger actuation are used to fire the canopy remover and, after a 0.3-sec. delay, the dual unit, manifolded rocket catapult. To increase reliability, the entire rocket catapult firing system has been duplicated from triggers to catapults and rockets. As the capsule moves up the guide rails on the cockpit bulkhead, a trip mechanism is used to fire a drogue parachute package into the airstream. In deploying, this primary stabilization device also serves to pull two stabilization booms out after the capsule has left the airplane. Fig. 4 shows the ejection system schematic.

The quick disconnect fitting between capsule and aircraft separates as the capsule moves upward. Since air pressure in the line to the pressurization system then drops to the ambient level, the source selector valve switches over to the capsule air bottle supply, if it is not already connected thereto. A trip mechanism actuated by capsule travel up the rails is used to trigger the oxygen system so that oxygen is drawn from the capsule bottle.

Dual aneroid-timing devices, also armed by a trip mechanism, are used to sense altitude and give appropriate time delay for deceleration to safe parachute-opening speeds. When the pre-set conditions have been satisfied, these devices initiate high-pressure gas flow to release the latches of the door covering the recovery parachute compartment in the bottom of the capsule. Stored air pressure then inflates a deceleration bag in this compartment which pushes out the recovery parachute container. As the parachute container is released, cables are pulled to jettison the stabilization booms and the drogue parachute attached to them.

Thus, the ring-slot recovery parachute, 38.5 ft. in diameter, is free to deploy. This configuration was selected to meet design requirements for minimum opening shock at high speeds and altitudes, rapid opening at low altitudes, and minimum packing space. If the automatic parachute compartment door release system does not operate, the occupant can use a manual override D-ring to perform this operation.

The aneroid-initiated high-pressure gas is also used to extend four telescoping booms that serve as landing stabilizers and flotation out-riggers. In addition, the same gas is utilized to actuate the second pre-ejection gas generator if it has not already been fired. The latter operation is performed to make sure that the capsule lands with no unfired ballistic devices since they could conceivably injure crash rescue personnel.

As the capsule passes through 10,500 ft., the oxygen regulator stops the flow of oxygen to the occupant's mask and switches over to "snorkel" operation, which permits the occupant to breathe outside air. At the same time, a negative pressure relief valve allows the capsule to come up to ambient pressure.

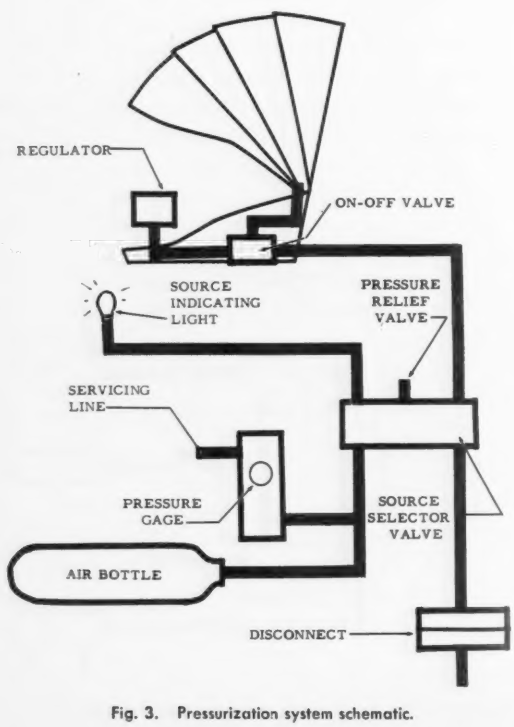


Fig. 3. Pressurization system schematic.

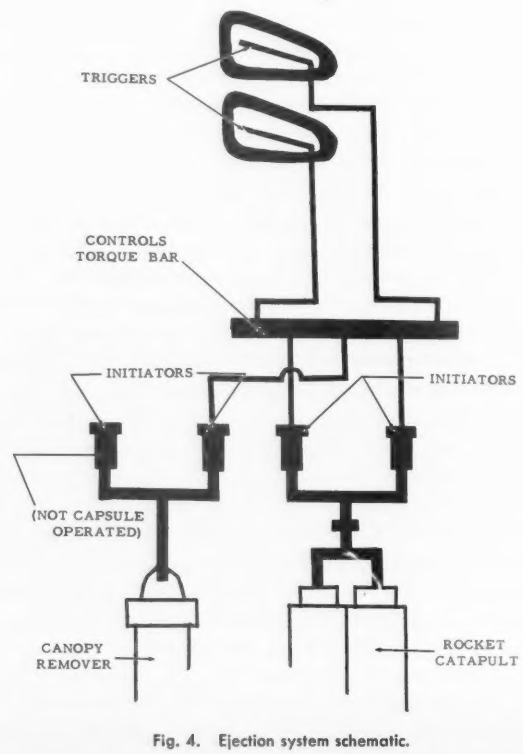


Fig. 4. Ejection system schematic.

Landing and Survival

Upon impact with the ground or water, the deceleration bag will compress, discharging the entrapped air through an orifice to absorb energy so that deceleration forces on the capsule occupant will not exceed human tolerances. After landing, the doors can be unlocked and opened from inside or outside the capsule. The required Strategic Air Command survival equipment is packed in hard-shelled evacuated containers, the most critically needed of which are accessible to the occupant with the capsule closed.

If the capsule should land in water, an immersion valve releases pressurized air from an air bottle to inflate a flotation balloon at the end of each outrigger boom. With buoyancy thus augmented and stability improved, the capsule is capable of staying afloat in Beaufort Scale 5 seas. Tests with live subjects in ocean waters have demonstrated that a downed flyer can survive for at least 72 hours in the floating capsule. If, because of rough sea conditions, the occupant must keep the capsule doors closed, the oxygen mask hose can be attached directly to the snorkel valve to eliminate the need for breathing through the oxygen regulator. Fig. 5 shows the flotation attitude of the capsule.

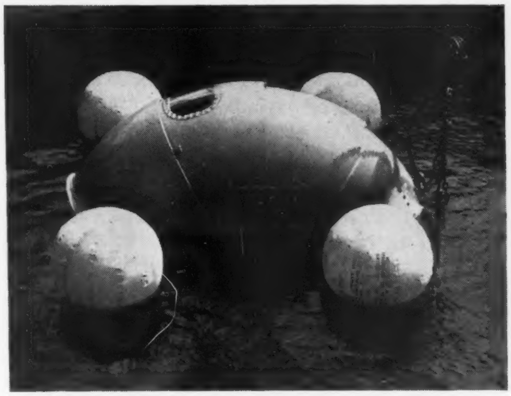
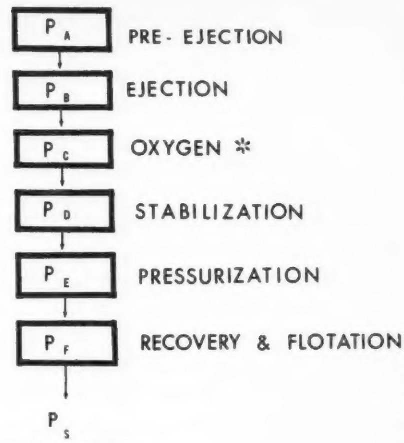


Fig. 5. Capsule flotation attitude.

Capsule Reliability and Maintainability

To assure the protection and safe escape in all circumstances that are fundamental design objectives of these B-58 capsules, Stanley Aviation has conducted a program to achieve maximum reliability and maintainability of the service articles.

The capsule, by specification, is to have an overall reliability of 0.97 at an 80 per cent confidence level. The pre-ejection operations are to have a reliability of 0.99 at the 80 per cent confidence level. A reliability model of the escape capsule is shown in Fig. 6. By combining analytical techniques, drawing reviews, and an extensive testing program, the reliability of the capsule is being monitored and improved as design progresses.



SPECIFICATION REQUIREMENT:
$P_S = P_A P_B P_C P_D P_E P_F = 97.0\%$
P_S = PROBABILITY OF SYSTEM FUNCTIONING
P_A P_B P_C P_D P_E AND P_F = PROBABILITIES OF SUBSYSTEMS FUNCTIONING

Fig. 6. Reliability model of the B-58 capsule. (*Not mandatory since pressurization is required.)

Maintenance of the capsule could be a costly and time-consuming process. However, use of modular subsystem designs and implementation of a program to achieve 97 per cent interchangeability of components means that repair of the capsule can be accomplished readily by subsystem or component replacement at squadron or field level. Preflight and postflight inspection requirements are being held to an absolute minimum consistent with safety. Reviews of drawings and developmental hardware are being used also to reduce the possibility of improper installations and connections by fulfillers of Murphy's law.

Further improvements in reliability and maintainability are expected by providing for adequate training, inspection, and maintenance equipment as part of this weapons subsystem development from the beginning. Coupling the results, particularly the training in use and maintenance of the capsules, with their designed-in provisions for improved crew efficiency in normal safe flight and for safe emergency use at all altitudes and flight speeds of the parent airplane leads to the conclusion that the B-58 crew capsules represent a major advance in escape systems.

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Part I outlines "the physical and mathematical bases required for the solution of optimum trajectory problems on an initial value basis."

Part II, to be published in February, will present "the development of the more general optimum boost relations which treat aerodynamic effects."

Optimum Rocket Trajectories

Part I—Initial Value Variational Solutions

Daniel O. Dommasch, AFIAS, and Roger L. Barron, AIAS

DODCO, Inc.

OUR PURPOSE here is to present methods of applying variational calculus to initial value optimum trajectory analysis. A great deal of literature is available describing the techniques of variational calculus as applied to boundary value problems. Indeed, the establishment of the Euler-Lagrange necessary conditions, as well as the imposition of various types of restraints, isoperimetric or otherwise, is normally presented entirely from the viewpoint that an analytic solution of the problem may be obtained in closed form between a prescribed set of initial and final conditions. Specifically, references 14–16 and 23 present a comprehensive development of variational theory from this viewpoint. References 1 through 9 present applied developments simplified to the extent that boundary value examination of optimum trajectories becomes possible; however, the techniques developed do not lead to general solutions in a numerical sense since no closed form solutions are found without the use of simplifying physical assumptions which are not generally valid for high-performance equipment. Thus the neglect of weight variations, the assumption that energy may be converted from one form to another without loss, the concept of a constant density atmosphere, the thought that trajectories may be composed of discontinuous arcs meeting specialized conditions are all open to question in a very general sense. The requirement that the equations of motion be satisfied at all times can never be legitimately eliminated, and any general solution must, continuously, satisfy all kinematic and dynamic restraints which apply to the system being analyzed.

References 10–13 and 17–22 consider the problem of continuous step-by-step solutions to optimum problems from several different points of view, and references 17–20 develop approaches and theorems pertinent to solution of the optimum problems on an initial value basis which requires the continuous satisfaction of the kinematic equations and the equations of motion at all points. Reference 21 employs dynamic programing techniques for solution on the assumption that normal load factor variation effects are negligible so that the equations of motion are imperfectly satisfied in that treatment.

Because there exist differences in opinion as to how one should apply variational techniques to problems which cannot be solved in closed form, it is necessary to delineate rather carefully the bases for any given method of attack, and in Part I we propose to set forth methods used for application of variational techniques to physically real initial value problems.

Necessary Conditions for a Solution

Although the derivation of the equations which define an optimum (extremum) solution for a given problem is presented most conveniently from the boundary value standpoint, it is clear that the set of differential equations which define an optimum for a specific problem must frequently be solved numerically in terms of initial values.

If we are faced with solution from an initial value standpoint, then it is clear that any mathematical conditions imposed at the terminal boundary cannot be reflected in our solution unless an analytic connection is established between the initial and terminal points. If such a connection can be found, there is no need to solve the problem in terms of initial conditions only; however, we are concerned with *real physical* (not idealized) problems, and an analytic connection cannot normally be assumed to exist on other than a hypothetical basis. To achieve a unique solution under these circumstances, we make use of the following precepts:

(1) For a dynamic system the equations of motion and kinematic relations govern all physically possible paths, including any class of real optimums which we may seek.

(2) The equations of motion and kinematic relations

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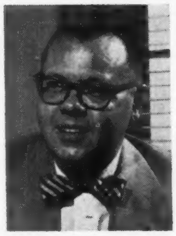

Mr. Barron, Vice-President of DODCO, has studied at Princeton University, Cambridge University in England, and the Massachusetts Institute of Technology, having received his Master's degree from M.I.T. in the area of aeronautical instrumentation and control. He has prepared a number of reports and papers in the fields of optimum trajectory analysis and optimum feedback servocontrol theory.

do not define a specific path unless the initial conditions are completely defined and unless a path or control function is imposed along with them. For optimum problems, the path function is obtained from variational techniques restrained by the equations of motion of the system.

(3) The path function does not replace the equations of motion in any sense; on the contrary, its purpose is to permit integration of these equations along a specific trajectory.

(4) The nature of the restraints must be fully comprehended to avoid either (a) trivial and/or discontinuous solutions and (b) the discarding of multiple solutions requiring a uniqueness condition for their separation.

(5) An initial value solution must satisfy the same restraints and equations at the initial point as at all following points so that the solution obtained is an optimum between any two points lying along the path. Thus we exclude all solutions of a discontinuous nature which are not physically realizable, and there can exist no discontinuous grouping of "subarcs" requiring either infinite longitudinal or normal accelerations.

The Euler necessary conditions for the existence of an unrestrained optimum are developed in all variational texts (see references 14–16, for instance) and can be expressed as follows in a form pertinent to this presentation.

We have given an integrand G, involving the two variables V and γ as functions of t, whose integral J is to be maximized or minimized between two points 1 and 2—i.e.,

$$J = \int_1 G(\dot{V}, V, \gamma, \dot{\gamma}, t)dt$$

is to be rendered stationary. [($\dot{}$) indicates a time derivative.]

The Euler necessary conditions to maximize J are[14–16]

$$(d/dt)(\partial G/\partial \dot{V}) - (\partial G/\partial V) = 0$$
$$(d/dt)(\partial G/\partial \dot{\gamma}) - (\partial G/\partial \gamma) = 0$$

In general the system described must observe some physical limitations which restrict the class of optimum solutions by restraining the possible values of G, and in this event the solutions of the Euler relations given above will not provide the desired answers since these will not satisfy the restraint conditions. The types of restraints which one can impose are quite varied—for instance, if we wanted to consider only that class of solutions providing a given change in V from point 1 to point 2, we would state that

$$\int_1^2 \dot{V}dt = \text{a constant}$$

This is a perimeter restraint which does not involve a coupling between the two dependent variables and, in accord with the derivations of reference 14, is properly introduced by forming a new integral

$$J_1 = \int_1^2 (G + \lambda \dot{V})dt$$

which is to be rendered stationary, where λ is a constant[14] and is called a Lagrange multiplier.

In this case, the Euler-Lagrange necessary conditions provide

$$(d/dt)[\partial(G + \lambda \dot{V})/\partial \dot{V}] - [\partial(G + \lambda \dot{V})/\partial V] = 0$$
$$(d/dt)[\partial(G + \lambda \dot{V})/\partial \dot{\gamma}] - [\partial(G + \lambda \dot{V})/\partial \gamma] = 0$$

Since this type of restraint does not reduce the degrees of freedom in any way, any number of restraints of this sort may be introduced.

On the other hand, if the system were restrained by a relation of the type $\dot{V}$ = constant, then both V and $\dot{V}$ would vanish from the formulation and our system would be free only in γ. If we are working with a dynamic system, we would have reduced our degrees of freedom by one.

Similarly, if $\dot{V} = k\dot{\gamma}$, we could eliminate either $\dot{V}$ or $\dot{\gamma}$ and evidently, since we can integrate this to get $V = k\gamma$ + constant, where k is also a constant, we could also eliminate V or γ. Again, our degrees of freedom are reduced by one. A restraint which couples first differentials in this fashion is called a holonomic restraint[25, 26] and, if it exists, serves to simplify analysis by elimination of a variable in the integrand. Evidently, two different holonomic restraints on a two degree of freedom system would destroy any possibility of variation since no freedom would be left.

If now we have a restraint such that $\dot{V} = q(t)\dot{\gamma}$ and $q(t)$ is unknown, we cannot integrate to eliminate V or γ, and hence we have eliminated a microscopic degree of freedom but not a macroscopic one.[25] In general, such a restraint as this can be introduced[14–16] by defining a function F as $F = \dot{V} - q(t)\dot{\gamma}$ and thus finding the extremums of

$$J_2 = \int_1^2 (G + \lambda F)dt$$

In this event λ is, in general, a function of time (unlike the case of a definite integral restraint). A restraint of this type is called anholonomic.[25]

If we now consider a restraint of the type

$$\dot{V} = m(t) + q(t)(\dot{\gamma})^n$$

where $m(t)$ is some unknown function of time, and n is any number having a value of 2 or more, we see that two or more values of $\dot{\gamma}$ can exist, satisfying the foregoing equation. Such a restraint is called pseudoholonomic[17–20] and is introduced using a Lagrange multiplier as in the case of an anholonomic formulation.

The existence of a nonlinear relation between $\dot{V}$ and $\dot{\gamma}$ requires the imposition of a least action uniqueness condition on the differential equations since, if this type of relation is properly introduced, it must lead to a multiplicity of variational answers.[17–20, 26]

It should be quite clear that in a two degree of freedom analysis no more than one restraint of the holonomic, anholonomic, or pseudoholonomic type can be introduced without destroying the problem.

The planar equations of motion of a boosted rocket (or of an airplane) subject to induced drag provide a *single* pseudoholonomic restraint by virtue of the fact that the induced drag is a function of the lift coefficient raised to some power n which is normally not an integer and which is greater than two. In the case of the boosted rocket, an anholonomic approximation is possible, but not so for an airplane.[17–20]

Specifically, for an airplane confined to flight at Mach Numbers less than 4, the standard equations of motion are

$$C_L = C_{LL}(\cos\gamma + V\dot{\gamma}/g)$$

$$F_e - qS(C_{D_e} + KC_L^n) - W[(\dot{V}/g) + \sin\gamma] = 0$$

where

C_L = lift coefficient = lift/qS
q = dynamic pressure
S = wing area
γ = inclination of flight path to horizontal
V = flight path velocity
g = acceleration of gravity
F_e = thrust
C_{D_e} = parasite drag coefficient (a function of Mach Number)
K = drag due to lift factor (a function of both C_L and Mach Number)
C_{LL} = level flight lift coefficient = weight/qS
n = an exponent of two or more
W = weight

Substitution of the first equation into the second shows that $\dot{V}$ and $\dot{\gamma}$ are coupled nonlinearly, and therefore the equations of motion provide a pseudoholonomic restraint on any optimum problem involving changes in both lift and drag.

It should be emphasized that the use of the equations of motion to restrain an optimum problem *does not provide more than a valid path function equation,* which still must be integrated *along with* the equations of motion and kinematic relations to provide a specific trajectory.

The variational principles so far presented are independent of the method of solution; however, we now must deal with the limitations imposed by the requirement for solution based on integration from prescribed initial conditions.

Initial Value Problems

Since, in an initial value problem, trajectories are completely defined in terms of the preceding developments, it is not possible to impose additional conditions associated either with discontinuities or with a "free" boundary. This means that one must integrate from a completely defined set of initial conditions to establish exactly what end conditions actually are achievable. Such procedures would be unnecessary if closed form solutions could be found for real problems, in which case one could invoke additional theorems[23] to provide a path immediately to a desired end point. In practice, however, we are forced to use either iterative techniques, relaxation procedures, or mapping techniques which serve to define envelope performance by systematically varying parameters to provide a complete coverage of obtainable performance.

If the nature of our problem introduces one or more Lagrange multipliers due to the existence of anholonomic or pseudoholonomic restraints, the value of the multiplier chosen at the outset *is a required initial condition* which one varies to shift the path termination conditions. *This is required both from the physical and mathematical standpoints* and may best be demonstrated by considering, at this point, the formulation of a simplified optimum boost problem in outline form which serves to demonstrate the overall procedures to be followed.

We wish to define that simplified class of optimum trajectories which will maximize the height attained by a rocket while achieving a desired set of end conditions on speed and on flight path attitude in an inertial reference system. If our engine burning time is fixed, the unrestrained integral which we must *maximize* is

$$h_G = \int_1^2 V_a \sin\gamma_1 dt \qquad (1)$$

where h_G = geometric height, V_a = velocity (absolute), and γ_1 = inclination of $\vec{V}_a$ to local horizontal.

Part II will deal with the more general problem involving relative velocity V_r and the relative flight path angle γ; however, the extra terms introduced by the procedure would serve only to obscure the points to be brought out here.

Since Eq. (1) is written in terms of absolute velocity and angle, its reference coordinate system has its origin at the center of the earth but does not partake of the earth's rotation about its own axis. Restricting ourselves to motion in a given inertial great circle plane, making the customary transformation of coordinates to the vehicle center of gravity, and assigning the positive x direction as along the velocity vector, we have the perfectly standard equations of motion which our vehicle must satisfy:

$$F_e \cos \alpha - m\dot{V}_a - mg \sin \gamma_1 = 0 \qquad (2)$$

$$F_e \sin \alpha - mg \cos \gamma_1 + mV_a(\dot{\theta}_1 - \dot{\gamma}_1) = 0 \qquad (3)$$

where

F_e = rocket thrust
α = angle between thrust line and the vector $\vec{V_a}$
m = mass
g = acceleration of gravity
$\dot{\theta}$ = $V_a \cos \gamma_1/h_a$
h_a = absolute height to earth center

Eqs. (2) and (3) are coupled through the appearance of the terms $F_e \cos \alpha$ and $F_e \sin \alpha$; however, since we have, for this simplified analysis, neglected lift and drag, there exists no other type of coupling. The nature of the coupling becomes apparent if Eq. (3) is solved for $\sin \alpha$ to give

$$\sin \alpha = (m/F_e)[g \cos \gamma_1 - V_a(\dot{\theta}_1 - \dot{\gamma}_1)] \qquad (4)$$

Now since $\cos \alpha = \sqrt{1 - \sin^2 \alpha}$, Eq. (2) becomes

$$F_e\sqrt{1 - (m/F_e)^2[g \cos \gamma_1 - V_a(\dot{\theta}_1 - \dot{\gamma}_1)]^2} - m\dot{V}_a - mg \sin \gamma_1 = 0 \qquad (5)$$

Eq. (5) shows that $\dot{\gamma}_1$ and $\dot{V}_a$ are dynamically coupled. If we stipulate that α lies in the first and fourth quadrants only, then Eq. (4) may be considered anholonomic without inadvertently discarding a solution.

Eq. (5) may be introduced directly into the problem in the form shown by employing a variable Lagrange multiplier; however, it is simpler to introduce only Eq. (2) directly while keeping in mind that α is defined by Eq. (4). Accordingly, we form the integral

$$J = \int_1^2 \{ V_a \sin \gamma_1 + \lambda[m(\dot{V}_a + g \sin \gamma_1) - F_e \cos \alpha]\} dt \qquad (6)$$

and seek its extremums.

If we designate by G the entire integrand of (6), our necessary conditions are

$$(d/dt)(\partial G/\partial \dot{V}_a) - (\partial G/\partial V_a) = 0$$

$$(d/dt)(\partial G/\partial \dot{\gamma}_1) - (\partial G/\partial \gamma_1) = 0$$

where

$$\partial G/\partial \dot{V}_a = \lambda m$$

$$(d/dt)(\partial G/\partial \dot{V}_a) = \dot{\lambda} m + \dot{m}\lambda$$

$$\partial G/\partial V_a = \sin \gamma_1 + \lambda F_e(\partial \alpha/\partial V_a) \sin \alpha$$

The effect of the coupling between Eqs. (2) and (3) is introduced by recalling that α is established by (4), and since $\dot{\theta} = V_a \cos \gamma_1/h_a$, Eq. (4) may be written

$$\sin \alpha = (m/F_e)\{g \cos \gamma_1 - V_a[(V_a \cos \gamma_1/h_a) - \dot{\gamma}_1]\} \qquad (7)$$

and

$$(\partial \alpha/\partial V_a) \cos \alpha = (m/F_e) \times [\dot{\gamma}_1 - (2V_a \cos \gamma_1/h_a)] = (m/F_e)(\dot{\gamma}_1 - 2\dot{\theta}_1)$$

Therefore $\partial G/\partial V_a = \sin \gamma_1 + m\lambda \tan \alpha\ (\dot{\gamma}_1 - 2\dot{\theta}_1)$. Accordingly, the first Euler condition yields

$$\dot{\lambda} m + \dot{m}\lambda - \sin \gamma_1 - m\lambda \tan \alpha(\dot{\gamma}_1 - 2\dot{\theta}_1) = 0$$

whence

$$\dot{\lambda} = \lambda\ [\tan \alpha(\dot{\gamma}_1 - 2\dot{\theta}_1) - (\dot{m}/m)] + (\sin \gamma_1/m) \qquad (8)$$

To form the second Euler relation, we have that

$$\partial G/\partial \dot{\gamma}_1 = \lambda F_e \sin \alpha(\partial \alpha/\partial \dot{\gamma})$$

From Eq. (7)

$$\partial \alpha/\partial \dot{\gamma} = mV_a/F_e \cos \alpha$$

and

$$\partial G/\partial \dot{\gamma}_1 = mV_a\lambda \tan \alpha$$

$$(d/dt)(\partial G/\partial \dot{\gamma}_1) = (\partial G/\partial \dot{\gamma}_1) \times [(\dot{m}/m) + (\dot{V}_a/V_a) + (\dot{\lambda}/\lambda)] + mV_a\lambda(d/dt)(\tan \alpha)$$

but

$$(d/dt)(\tan \alpha) = \dot{\alpha}(1 + \tan^2 \alpha)$$

and from Eq. (7)

$$\dot{\alpha} = X_1 + X_2\ddot{\gamma} \qquad (9)$$

where

$$X_1 = \left(\frac{\dot{m}}{m} - \frac{\dot{F}_e}{F_e}\right) \tan \alpha + \frac{X_2}{V_a}\left[\dot{g} \cos \gamma_1 - 2\dot{\theta}_1 V_a + \dot{\theta}_1 \frac{V_a^2 \sin \gamma_1}{h_a} + \dot{\gamma}_1\left(\dot{V}_a - g \sin \gamma_1 + \frac{V_a^2 \sin \gamma_1}{h_a}\right)\right]$$

$$X_2 = (m/F_e)(V_a/\cos \alpha)$$

Similarly

$$\partial G/\partial \gamma_1 = V_a \cos \gamma_1 + \lambda\ \{mg \cos \gamma_1 - m \tan \alpha \sin \gamma_1[g - (V_a^2/h_a)]\}$$

and the second Euler relation solved for $\ddot{\gamma}$ provides

$$\ddot{\gamma} = \frac{(V_a/\lambda)(\cos \gamma_1 - m\lambda \tan \alpha) - m\left(\tan \alpha\ \{(\dot{m}/m)V_a + \dot{V}_a + [g - (V_a^2/h_a)] \sin \gamma_1\} - g \cos \gamma_1\right)}{X_2 m V_a \sec^2 \alpha} - \frac{X_1}{X_2} \qquad (10)$$

Thus the Euler relations constitute a path function by providing differential equations for $\ddot{\gamma}$ and $\dot{\lambda}$.

Eqs. (8) and (10) for $\dot{\lambda}$ and $\ddot{\gamma}$ together comprise a path function. To provide a determined path these must be combined with the equations of motion which define $\sin \alpha$ and $\dot{V}_a$, the kinematic relationships for $\dot{h}_a$ and $\dot{\theta}$, as well as the design specified equations for $\dot{F}_e$ and $\dot{m}$, and the Newtonian equations for g and $\dot{g}$. The kinematic relations are simply

$$\dot{h}_a = V_a \sin \gamma_1 \tag{11}$$

$$\dot{\theta}_1 = V_a \cos \gamma_1 / h_a \tag{12}$$

The equations of motion yield

$$\sin \alpha = (m/F_e)[g \cos \gamma_1 - V_a(\dot{\theta}_1 - \dot{\gamma}_1)] \tag{13}$$

$$\dot{V}_a = (F_e \cos \alpha)/m - g \sin \gamma_1 \tag{14}$$

Design characteristics provide

$$F_e(t) \quad \text{and} \quad \dot{F}_e \tag{15}$$

$$\dot{m} = F_e(t)/V_{ex} \tag{16}$$

where the exhaust velocity V_{ex} is determined by the engine configuration.

The Newtonian definition for a spherical earth gravitic potential is

$$g = g_0(R_e/h_a)^2 \tag{17}$$

where

g_0 = sea-level reference value of g, the gravitic acceleration of gravity
R_e = earth radius
h_a = absolute altitude

From Eq. (17)

$$\dot{g} = -2g(\dot{h}_a/h_a) \tag{18}$$

The complete set of required initial conditions evidently comprises the group h_a, V_a, γ_1, θ_1, $\dot{\gamma}_1$, λ, and m with the initial $\dot{V}_a$ given by Eq. (14).

Because of the coupling of the equations of motion, we see that $\dot{V}_a$ cannot be separately specified (as it could be if the equations of motion did not constitute an anholonomic condition) and that therefore λ provides the fourth physical initial value of the dynamic group γ_1, $\dot{\gamma}_1$, and V_a. Because our coupling is anholonomic, $\ddot{V}_a$ could have been specified in place of $\dot{\gamma}_1$, in which case the equations of motion would have served to define $\dot{\gamma}_1$ initially.

With the specified initial conditions, we have precisely sufficient equations for integration on a continuous step-by-step basis, and therefore solution on an initial value basis is completely defined.

Any valid numerical technique of solution may now be applied to the foregoing set of relations, the simplest technique being direct Taylor series integration. When Taylor series are used for integration, it is desirable to differentiate the equations for $\dot{V}_a$, $\dot{h}_a$, $\dot{\theta}$, $\dot{m}$, and $\dot{F}_e$ (if it exists) to provide consistent second-order accuracy, or one may use looping techniques to provide equivalent results.

Conclusions

Part I briefly outlined the physical and mathematical bases required for the solution of optimum trajectory problems on an initial value basis. Although a simple example was chosen to illustrate the techniques and principles, more involved problems are solved in the same fashion, except that the mathematical manipulations become considerably more complex. In the event that a pseudoholonomic condition is involved, one requires, in addition to the relations dealt with here, a uniqueness condition which is normally provided by the principle of least action.

Part II of this paper, to be published in February, will present the development of the more general optimum boost relations, which treat aerodynamic effects and are based upon equations of motion referenced to the rotating navigational or earth great circle axis system. Results of numerical analyses will also be presented. Inasmuch as we know of no comparable valid numerical results obtained by use of the other suggested optimum procedures mentioned at the beginning of Part I, comparison with these is not possible.

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(*Continued on page 60*)

The aerodynamic characteristics of discus bodies, such as surface/volume ratio and interference cleanness together with the suitability for V/STOL fan operation, promise a considerable improvement in flight performance and spot-to-spot traffic.

The Discus Body

and Its Application to V/STOL Aircraft and Space Vehicles

Martin Gerloff, MIAS

General Electric Company

THE present state of the aircraft design—namely, voluminous fuselages with small wings and engine nacelles on long pylons—does not necessarily represent a final solution, although modern airliner types and the latest executive aircraft are already looking very much alike.

It is felt that more emphasis should be placed on the improvement of the flight performance through better aerodynamic quality and not through additional power. All contributions achieved by aerodynamic improvements result in smaller, faster, and more economical transport vehicles. Attempts have been made to find a more favorable flight configuration which could be called an optimized flight body.

Optimization Study

As the main percentage of the drag is created by friction, a reduction of the wetted surface will improve the flight performances. Present-day airplanes are reaching high subsonic flight speeds, and a low disturbance level of the local supersonic velocities becomes desirable. Finally, the take-off and landing characteristics such as STOL or VTOL capabilities deserve special consideration.

With these features in mind, a most favorable relation between useful volume V and wetted surface Ω is wanted. As is generally known, the sphere would be superior in this respect; Fig. 1 shows the increase in volume and wetted surface as a function of the sphere diameter. These values serve only for reference purposes, indicating merely the cubic law and the well-known fact that the larger airplane would be more favorable. Modern commercial transport airplanes have a useful volume of approximately 17,700 ft.^{3} (500 meters^3); for this region the sphere could offer a superior surface/volume ratio of $\Omega/V = 0.6$. However, the sphere does not represent a useful aerodynamic shape.

On the other hand, in order to achieve good aerodynamic efficiency, it is desirable to eliminate as much surface as possible which does not contribute toward a

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Symbols

GW	= gross weight, lbs.
S	= aerodynamic wing area, ft.^{2}
GW/S	= wing loading, lbs./ft.^{2}
V_0	= flight velocity, m.p.h.
q	= dynamic pressure, $(^1/_2\,\rho\,V_0^2)$
L/D	= lift/drag ratio, lbs./lbs.
C_L	= lift coefficient = lift/$q \times S$
C_D	= drag coefficient = drag/$q \times S$
Ω	= wetted surface, m^2
V	= useful volume, m^3
Ω/V	= surface volume ratio, m^{-1}
c_f	= friction coefficient
f	= drag area = $C_D \times S = D/q$, ft.^{2}
AR	= (wing span)^2/(aerodynamic area)
t/c	= thickness/chord ratio
M	= V_0/a = Mach Number = (flight velocity)/(velocity of sound)
$M_{\text{div.}}$	= critical Mach Number at drag rise

reduction of the induced drag and the minimum speed by means of increased lifting area. The fuselage, for instance, causes drag without noticeable contribution to the lift.

If a sphere is flattened to a so-called discus shape so that a proper t/c ratio is attained, a very promising flight body should result. Fig. 2 gives some important characteristic data plotted as a function of the thickness/chord ratio. With a given t/c ratio and the desired useful volume, it is possible to evaluate the diameter of the discus body and the surface/volume ratio (Ω/V),

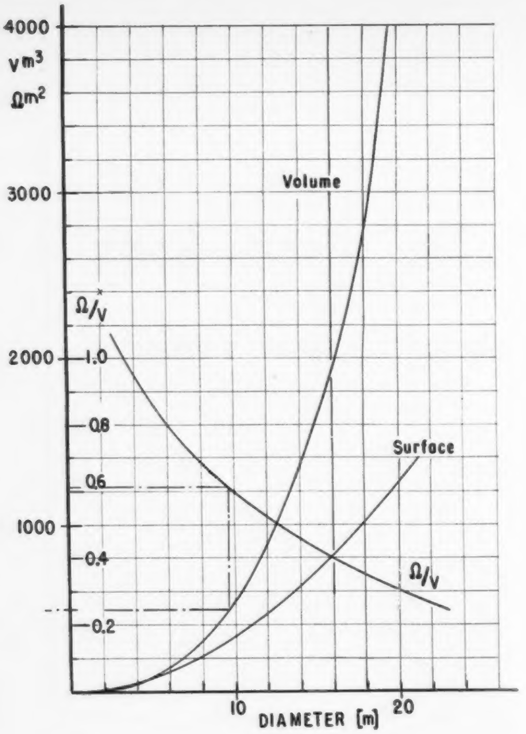

Fig. 1.

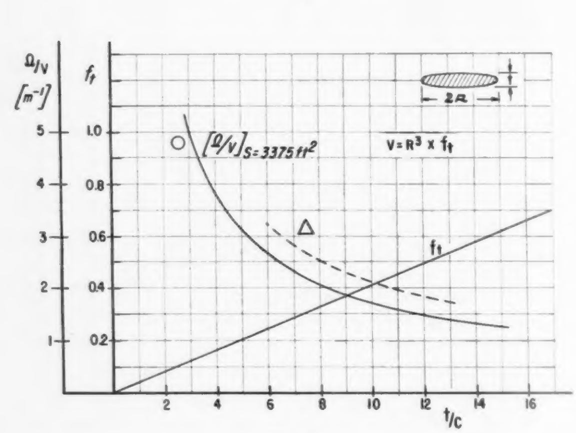

Fig. 2.

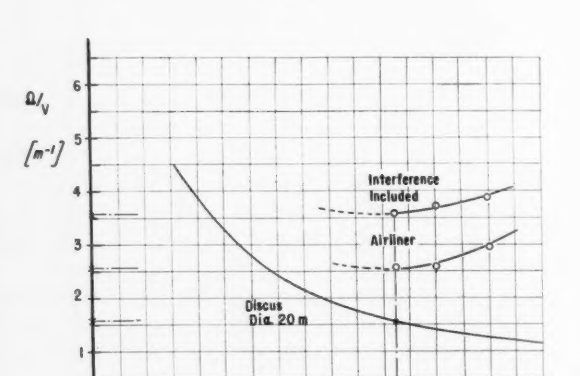

Fig. 3.

Table 1.

Useful Volume	Sphere	Discus	Cross Design
17,000 ft.[3]	0.6	1.55	2.55 (3.5)

thereby allowing a comparison with conventional cross designs.

A comparison with present commercial transport airplanes shows a considerable advantage of the discus body with respect to the surface/volume ratio, as well as to the aerodynamic efficiency. Fig. 3 indicates the surface/volume ratio of several airliners as a function of the t/c ratio—a measure for the aerodynamic quality and abilities. If interference is considered, the surface/volume ratio of a present-day jet airliner could be improved from 3.5 to 1.55 together with a decrease in wing loading of approximately 50 per cent. Apart from its bearing on the landing and take-off characteristics, this would favorably influence the critical Mach Number ($M_{crit.}$) and the ideal altitude which are the decisive parameters for the economic operation of jet-propelled aircraft.

The comparison of Ω/V ratios is limited to airplanes based on the same useful volume. The values shown in Table 1 have been obtained for an airliner.

Performance Analysis

The estimation of direct operating cost for a capacity of payload is generally accepted as a measure in assessing the economy of air transport. The results are usually presented as "cents/ton-mile" or "cents/seat-mile" for a given stage distance (statute miles). Another base of valuation is the productivity which is defined as the payload times velocity, divided by gross weight minus payload.

However, the decisive measure in comparing different configurations is the amount of drag generated by transporting a useful load through the air. The following parameter may be applied here:

$$\frac{\text{Payload}}{\text{Drag}} = \frac{\text{Payload}}{\text{Gross Weight}} \times \frac{\text{Lift}}{\text{Drag}} = \frac{\text{Payload}}{\text{Gross Weight}} \times \frac{C_L \times S}{f}$$

This parameter will have its optimum value when payload over gross weight and lift over drag are at their maxima.

The first term, payload/gross weight, is determined by design factors, such as total structure weight, location of the payload, equipment, and fuel. No stress studies have been carried out so far, but it is easy to see that, for the compressed form of the discus body, an essential gain in airframe weight can be attained when compared to a conventional cross design.

Furthermore, the required range and the fuel consumption have some influence. Especially in the operation of long-range jet aircraft, each reduction in fuel consumption—i.e., by the application of better aerodynamics—permits a considerable increase in payload and, in turn, an increase in the payload/gross weight ratio.

The second term, the L/D ratio, generally written by means of aerodynamic coefficients, is considered the aerodynamic efficiency factor of a vehicle. To generate the required C_L, it is necessary to overcome the entire C_D of the vehicle. The total drag of an airplane is here evaluated by

$$\Sigma f = C_f \times \Omega + \frac{C_L^2 \times S}{\pi \cdot e \cdot AR}$$

Values of the total drag area are directly comparable while aerodynamic coefficients may be related to different wings.

Special consideration must be given to the low aspect ratio ($A\!\!R$ = 1.275) which is characteristic of all discus bodies and to its influence on the economic flight performance. In order to obtain some comparative values, polar curves have been plotted in Fig. 4. These data refer to a present-day executive transport aircraft, which has also been carried out as a discus design.

Referring to the same useful volume, the friction drag, as a function of the wetted surface, always remains smaller for the discus configuration. However, the induced drag increases much faster with C_L, and the polar curves show quite different characteristics. The considerably lower C_D coefficient of the discus at high flight velocities is obvious. Besides, the optimal C_L/C_D ratio belongs to a lower C_L coefficient, a fact which may favorably influence the flow pattern at high subsonic and transonic velocities.

Gross weight divided by the aerodynamic area determines how the lifting device is loaded. For discus configurations, the area and, in turn, the lifting coefficient C_L are linked together with design factors since wing and fuselage have become a unity. The required useful volume together with the t/c ratio determine the wing area and, in turn, surface drag and induced drag.

Some estimated flight performances reveal that the lift/drag ratio of the discus body may become superior to that of the wing-fuselage design even at the optimum altitude and continues to improve with increasing flight velocity. Assuming equal gross weight, engine rating, and payload, the discus airplane will reach the desired cruising speed at low altitude and with less thrust, and will accomplish larger ranges.

Jet airplanes cruising at high subsonic speeds operate best at ideal altitude, where speed for optimum L/D occurs simultaneously with the speed for drag rise ($M_{\text{div.}}$). At lower cruising speeds, long-range flying is usually done at velocities which are 20 to 30 per cent above the speed for the best L/D ratio—facts that make the advantages of the discus body even more evident.

It seems that the low aspect ratio, characteristic of all discus bodies, becomes tolerable because of the improved cleanness factor, the high flight speed, and the relatively low wing loading. The lifting capability of the discus results in an outstanding maximum/minimum flight speed ratio, which may favorably influence the flight performance and the take-off and landing procedures.

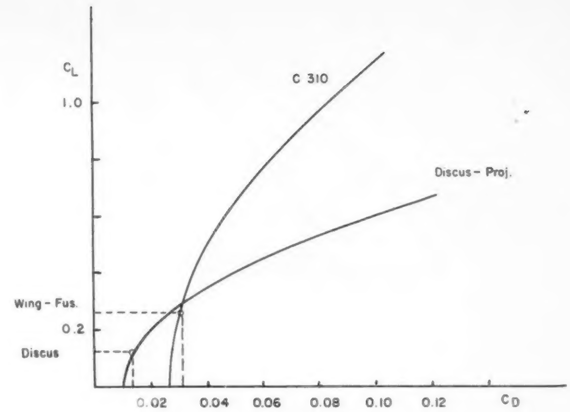

Fig. 4.

Aerodynamic Features

Numerous parameters are involved in determining the features of a wing and the features of a circular planform. Quite a few wind-tunnel tests may be needed to understand the inherent characteristics of the discus shape as a body in airflow. To preserve the natural shape of a discus and its enclosed volume at least to a certain extent, the conventional airfoil section has to be modified somewhat; however, simple analytical methods are already available.

The whole discus plane acts as a wing, comparable to the all-wing designs. Their especially critical aspects in stability and control have been reported in technical literature for years. The discus body, too—whether in rolling, pitching, or yawing motion, in symmetric or in skidding attitude—has no natural stability whatsoever. This might be the main reason that the application of discus configurations has been avoided to date. However, the situation has changed in the meantime. Reliable autostabilizer units have been developed and are available to provide artificial stability. All discus design studies have VTOL capability or may be provided with it. As no flight body has natural stability in the VTOL and hovering procedure, a reliable artificial stability must be available anyway.

With the application of conventional symmetrical wing sections, the neutral point would be located in 24 to 25 per cent of the center chord line, according to wind-tunnel tests. However, an asymmetric position of the center of gravity—namely, ahead of the neutral point as a stability requirement—results in disadvantages such as asymmetric installation of the VTOL fan and limitations in the full use of the discus volume.

Properly cambered wing sections are able to create a neutral point in the center of the discus body. But it seems advantageous to locate the center of gravity behind the neutral point—i.e., to fly in an unstable condition, supported by an autopilot. In this way, we gain in maximum lift and have already counteracted the back motion of the neutral point in the event of supersonic flight. The control system provides an artificial feeling anyway, and the pilot can no longer be endan-

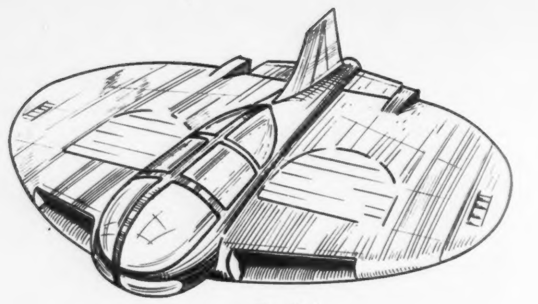

Fig. 5(a).

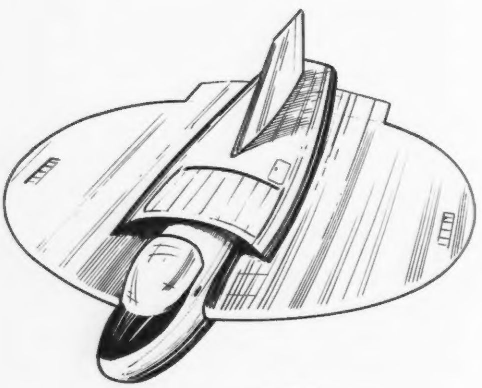

Fig. 5(b).

gered by a reversed stick force of an unstable flight system.

However, a conventional stabilizer (fin-rudder) has shown ineffective control response for the all-wing design and even becomes useless in VTOL and hovering procedures. Therefore it is suggested that roll, pitch, and yaw control will be provided by jet reaction where guide vanes deflect the jet exhaust in the proper direction and at maximum possible distance from the center of gravity. In addition, this solution saves friction and interference drag.

Of course, emergency provisions must be made for the event of an engine failure. A simple solution would be the application of a brake parachute acting on a rod. The stabilizing effect of the parachute together with elevator and aileron makes a deadstick landing possible.

Concerning supersonic velocities, the discus body—as a very low-loaded lifting device—should achieve excellent flight characteristics in high subsonic and transonic regions. Because the increased differences in the velocity field between the upper and the lower part of the wing (due to larger angles of attack) interfere with the pressure distribution, all deviations in the longitudinal momentum are considerably intensified.

Application of the Discus Body

As mentioned earlier, it is assumed that all discus design studies have VTOL capabilities. The idea of converting a conventional wing-fuselage design into a VTOL vehicle simply by installing fan wheels in the plane of the wings does not represent the best possible flight configuration. The various items which influence the performances of a VTOL project—such as (a) extremely low structure weight, (b) hidden installation of the fan, (c) low minimum flight speed, and (d) best aerodynamic efficiency—are demanding a new design concept which has led to the application of the discus shape. Based on its superior surface/volume ratio and aerodynamic characteristic, the VTOL-discus vehicle shows very advanced flight performances.

Utility Vehicle and Army Battle Horse

As an interesting application of the discus design, project study Fig. 5(a) shows a utility vehicle and Fig. 5(b) a modification as an Army vehicle.

According to recent publications, an Army aerial jeep might be designed as a two-fan, pure thrust-supported vehicle—i.e., only the reaction force of a downward-directed air stream is applied to generate the lift force.

However, it must be kept in mind that all fan wheels have to operate under the influence of a superimposed flight velocity, and irregularities of flow at the fan sections during the revolutions must be compensated for in order to avoid a dangerous roll torque. Vehicles with the fan discs rectangular to the flight velocity and a slipstream deflection behind the fan might achieve reasonable flight velocities; however, the flight performances must remain poor.

If we examine the L/D ratio as the aerodynamic efficiency of the vehicle, we will find that, for a fan as a lifting device, the maximum lift/thrust ratio can only be one which will be achieved in a hovering position. This amount is certainly very low compared with the aerodynamic efficiency of a wing ($L/D = 10$). The present development of pure fan-supported vehicles seems to be a misleading conception.[1]

Table 2.

Items	Conventional Utility Aircraft	Discus Utility VTOL
Engines	Piston Engines (2 × 240 hp.)	Turboprop Engines (2 × 250 hp.)
Passengers	4	4
Wing area, ft.²	175	179
Aspect ratio	7.3	1.45
Wing loading, lbs./ft.²	26.2	12.9
Power loading, lbs./hp.	9.6	4.6
Weight empty, lbs.	2,925	1,410
Payload, lbs.	960	760
Fuel, lbs.	815	130
Gross weight, lbs.	4,700	2,300
Max. overload (STOL), lbs.	. . .	3,000
Wetted surface, ft.²	854.7	531.3
Drag area f, ft.²	5.7	2.9
Max. velocity, m.p.h.	232	305
Cruis. velocity, m.p.h.	204	273
Landing velocity, m.p.h.	70	0/65
Range, miles	890	120 (STOL 655)
Miles/gal.	7.3	6.8
¢/10 miles	44¢	32.5¢

Table 3.

Passengers	1 210 lbs. +	2 420 lbs.	3 570 lbs.	4 760 lbs.
VTOL gross weight, lbs.	2,300	2,300	2,300	2,300
Fuel load, lbs.	500	470	320	130
Range, miles				
sea level	475	447	304	124
STOL gross weight, lbs.	3,000	3,000	3,000	3,000
Fuel load, lbs.	1,030	1,030	880	690
Range, miles				
sea level	980	980	835	655
10,000 ft.	1,060	1,060	905	705

The wing still represents by far the most economic lifting device available, and a winged design is always preferable to a pure fan-supported vehicle. Moreover, every VTOL aircraft should have STOL-capabilities, and a spectacular improvement in payload and range would be achieved even for a short take-off run.

Table 2 summarizes the results of a performance computation and allows a comparison between a present-day twin-engine utility aircraft and a VTOL-discus. The given performance data are based on the polar curves shown in Fig. 4.

The influence of induced drag on the flight performance is so insignificant that it does not seem worth while to invest weight in increasing the aspect ratio.

In VTOL design weight is expensive.[2] The VTOL gross weight and subsequently the VTOL range must be reduced. To overcome this limitation, it is important to provide a fuel overload to extend the range by means of a V/STOL operation. For each cross-country flight, a stop will be made at a country fuel station outside the city which provides a take-off strip for its customers. In case of an STOL operation, the range capability improves, as shown in Table 3.

Besides the improvements in range, the advantages of a good climbing performance and a low velocity transition show clearly the importance of providing a VTOL project with an efficient aerodynamic lift system.

A family "automobile" of the future may have a gross weight of 2,300 lbs. (STOL GW = 2,700 lbs.). By increasing the engine rating to only 500 hp. we will be able to travel at a flight velocity of 250 m.p.h.—five times the block speed made on the road today—and that also as spot-to-spot traffic. Moreover, the lifetime range may easily be improved from the 100,000 miles of an average car to one million miles.

The fuel consumption of the different vehicles amounts to

American car	17 miles/gal.	19¢/10 miles
Utility aircraft	7.3 miles/gal.	44¢/10 miles
VTOL-discus	6.8 miles/gal.	32.5¢/10 miles

The turboprops of the VTOL-discus are able to burn the lower priced JP4 fuel. Considering the improvement in cruising speed, the cost increase is reasonable.

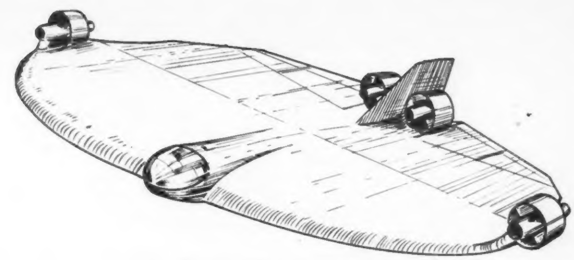

Fig. 6. Airliner configuration.

With reference to military application, the VTOL and hovering capabilities combined with good horizontal flight performances offer a great potential to the Army by actually introducing the third dimension into its tactical operation and thereby increasing its mobility in the combat area. Mechanized warfare will experience such a speed-up that conventional tools like jeeps and tanks will become as obsolete as horses in the era of motorcars. An Army soldier of the future will set foot on enemy soil only at operation bases; the attack of a battle line may be compared to the steps of a giant distributing death and destruction on his way.

Throughout history, superior mobility has always been the answer to overwhelming forces, and the country which is first in adopting the third dimension and its mobility in tactical operations will dominate. Of course, an entirely new "car-style" aircraft production must be created to materialize such a private and military VTOL-aircraft program.

Airliner

The project study of Fig. 6 represents a discus airliner. In the comparison with a present-day wing-fuselage design, equal wetted surfaces and approximately equal cruising speeds have been assumed. The results of the performance estimation are listed in Table 4.

Table 4.

Items	Present-Day Airliner	Discus Airliner
Engines	4 Turboprops (4 × 5,150 hp.)	4 Turboprops (4 × 5,500 hp.)
Passengers	154	250 (350)
Wing area, ft.^{2}	2,080	5,540
Aspect ratio	9.8	1.48
Wing loading, lbs./ft.^{2}	98	36.2
Power loading, lbs./hp.	9.95	9.1
Weight empty, lbs.	101,194	71,700
Payload, lbs.	32,400	53,000
Fuel, lbs.	71,406	75,300
Gross weight, lbs.	205,000	200,000
Max. overload, lbs.	...	250,000
Wetted surface, ft.^{2}	11,850	12,600
Volume, ft.^{3}	15,250	45,500
Drag area, ft.^{2}	57	42.7
Max. velocity, m.p.h.	445	510
Cruis. velocity, m.p.h.	400	440
Landing velocity, m.p.h.	...	91
Range (max.), miles	4,400 (5,000)	4,800 (6,450)
Miles/gal.	0.44	0.42
$/10 miles (fuel cost)	$5	$5.25

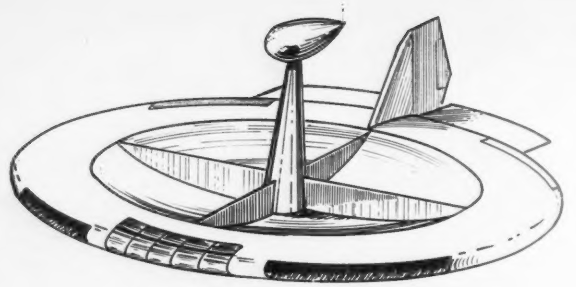

Fig. 7. Solar discus.

An examination of these data shows that, besides lower wing loading, the discus form actually generates less drag per useful volume or that, referred to the same wetted surface, much more payload volume can be carried. If we refer to an equal payload and range, which would represent a useful work (miles × lbs.), the discus vehicle may operate as a smaller airplane with less engine power and fuel consumption flying at a lower ideal altitude. This also means that a discus bomber will perform a longer range.

A 200,000-lb. gross weight has been selected to allow a comparison with present-day airliners, otherwise considerably larger take-off weights are recommended. Provisions can be made with little weight penalty to make landings on water surfaces, too.

It is uncertain whether VTOL capability will be worth while in an airliner operation and if a consignor will be willing to pay for it. With respect to safety, high take-off and landing speeds represent a hazardous procedure. On the other hand, the power-on landing, carried out in a very steep approach angle, is not the safest landing either. It is felt that a landing speed reduced to a reasonable amount—either by low wing loading or a fan support—and a favorable approach angle will bring best results. Our main efforts should be made in increasing acceleration and deceleration power to shorten the field length.

Space Vehicle

Between the 17-mile altitude covered by today's jets and the 200-mile orbits of the earth-circling satellites there exists a still uncovered region, and it seems that the discus is extremely capable of flying in the rarefied environment of this important twilight zone.

At very high altitudes (50 to 90 miles), the mean free path length becomes comparable to the vehicle dimension (diameter), and the flow conditions are similar to the picture visualized by Newton—i.e., the air particles hit the body like small bouncing balls. Thus the flat undersurface of the discus would represent an effective lifting device in the rarefied environment. A vehicle riding on air particles with the molecules so far apart that the procedure can be compared to the gliding of a boat on a water surface should experience even a better lift/drag ratio than a vehicle flying at lower altitudes.

In cases where density and velocity are not properly adjusted, the heating determines the configuration of the vehicle and the flight program. The discus planform, in addition to its relatively distinct blunt-nose radius, incorporates an extended leading edge which alleviates the local heating.

The return to earth may be carried out along a ballistic or a controlled glide trajectory. In a ballistic path, the vehicle experiences only gravity and inertia forces, but in a glide trajectory the vehicle descends and decelerates controllable through the earth's atmosphere, and aerodynamic lift plus centrifugal force counterbalance the weight.

To keep the structure from disintegrating, a vehicle should be designed to produce maximum drag associated with maximum lift, which is a characteristic feature of the low aspect ratio circular planform. As heat input is a function of the deceleration, the pilot will have to control the re-entry operation by adjusting lift and drag with the angle of incidence depending on flight velocity and density of the air.

Finally, the study in Fig. 7 shows a project which could be called a solar discus. The whole structure is inflatable and built up with Wagner beams where all vertical stiffeners have been avoided by means of inside pressure. For power, a closed-water turbine system has been assumed which is heated by solar energy reflected from a mirror inside the discus. This energy source has the unusual features of remaining constant with altitude and of operating without fuel.

The horsepower required to keep the discus body floating (C_L/C_D opt.) always remains smaller than the generated horsepower. Up to high altitudes (100,000 ft.) there is always a considerable reserve of excess horsepower available for climbing.

Unfortunately, the propeller as thrust generator becomes inefficient in the rarefied environment considered here, and other propulsion devices have to be applied—for instance, a surface jet (boundary-layer jet). Nevertheless, a discus would be an excellent vehicle to bounce on the air level—for example, as a flat stone on the water surface.

Reaching rotational speed of the earth (0.3 m.p.s.-1,080 m.p.h.), we would have the power source, the sun, always overhead, and inexpensive means of traffic around the earth would be possible. Such a system might lead to an easier way of space exploration, compared to the present-day multistage rocket systems.

Conclusions

The reduced wetted surface of the discus body referred to a useful volume and the increased efficiency due to the diminished interference result in an aerodynamic improvement which must yield smaller, faster, and more economical transport vehicles.

Discus bodies prove to be favorable for VTOL operation. The VTOL capability is combined with a good lift/drag ratio for cruising, climbing, and STOL range—which renders the discus superior to all rotary-wing designs. The high efficiency in lift contribution also influences favorably the transition procedure.

(Continued on page 60)

A discussion of the problem of obtaining the statistical distribution of the dynamic life of a unit taken from stock. "This distribution would provide an answer to certain questions regarding the reliability of the given device."

The author also describes a method for calculating the distribution of the dynamic life in a specific case.

The Distribution of the Dynamic Life

L. V. Toralballa

New York University

IN AN EARLIER PAPER[1] the author considered the following problem:

Let the length of effective life y of a given engineering device, when subjected to a stress of constant magnitude x, be given by a function $f(x)$. Let the device be now subjected to a stress course given by $x = F(t)$, where t is the time after the start of the course, and $F(t)$ is a known function. The problem was to determine h, the total length of effective life of the device when subjected to this stress course. It was found that h is given by an equation of the form

$$\int_0^h \frac{dt}{f[F(t)]} = 1$$

The value of y corresponding to a given value of x was called the static life corresponding to that value of the stress. The value of h was called the total dynamic life. In this paper we shall refer to it simply as the dynamic life.

In the case of a unit taken at random from a well-defined stock of such devices, we may take the function $f(x)$ as giving the average length of the static life corresponding to each value of the constant stress x. In fact, the function $f(x)$ would have been determined from statistical data obtained from a set of tests to destruction of units from such a stock. Now, for a unit taken at random from a stock, the actual static life corresponding to a given value of the stress x would be a statistical variate. As we do not change units in mid-course but keep the same unit throughout, we may, as an approximation, assume that if the static life of the particular unit at one value of the stress x is, say, 10 per cent greater than the average for that value of the stress, then its static life at any other value of the stress is also 10 per cent greater than the average for that stress—i.e., we assume that

$$r = \frac{\text{actual static life at stress } x}{\text{average static life at stress } x}$$

is a constant for a particular unit.

With the assumption made above, we may take into

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consideration the actual static life of a unit (taken at random from stock) in the following manner.

The dynamic life h of the unit is now given by

$$\int_0^h \frac{dt}{rf[F(t)]} = 1$$

Thus h is a function of r. For different units from the same stock, r may well be different; thus the dynamic lives of the units would also be different. One of our problems in the present paper (Section I) is to obtain the statistical distribution of the dynamic lives. This distribution would provide an answer to certain questions regarding the reliability of the given device.

In Section II of this paper, we take into consideration the variability not only in the actual static lives but also in the values of the stress at fixed times. (For instance, in the case of a missile, where the ambient atmospheric pressure is the relevant stress, even if the trajectory is invariant, the stress holding at the time t of flight would still be varying.) In this connection we shall take the function $x = F(t)$ as indicating the average value of the stress met at the time t. We shall also describe a method for calculating the distribution of the dynamic life in this case.

(I) Variability Restricted to Static Life

As mentioned above, we assume that the ratio

$$r = \frac{\text{actual static life at stress } x}{\text{average static life at stress } x}$$

is a constant. The equation for the dynamic life is

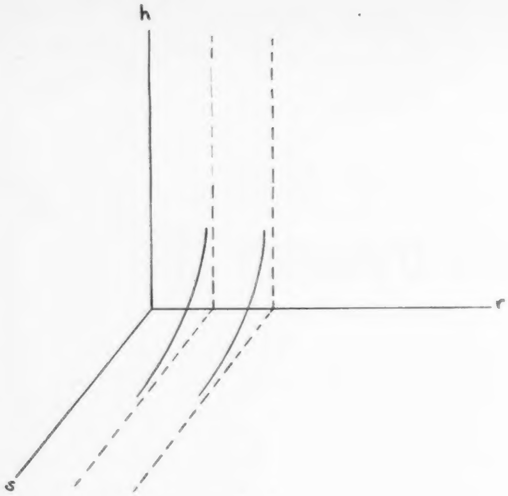

Fig. 1.

then

$$\int_0^h \frac{dt}{rf[F(t)]} = 1 \qquad \text{or} \qquad \int_0^h \frac{dt}{f[F(t)]} = r$$

Let $g(t) = 1/f[F(t)]$. We are interested, first, in obtaining the statistical distribution of r. This depends upon the distribution of the actual static life y at any given value of the stress x. As indicated in an earlier paper,[2] there is a stage in the development of an engineering device when this distribution of y is adequately represented by the probability density function $(1/\bar{y})e^{-y/\bar{y}}$, where $\bar{y}$ is the average static life under the stress x, and y is the actual static life variate at this stress.

Assuming this distribution of y to hold, we obtain that of r in the following manner:

From $(1/\bar{y})e^{-y/\bar{y}}$, we obtain $(1/\bar{y})e^{-r}$. Since $y = \bar{y}r$, $dy = \bar{y}dr$. Thus the probability density differential of r is given by $(1/\bar{y})e^{-r}\bar{y}dr$, and so the probability density function of r is given by e^{-r}.

Since $\int_0^h g(t)dt = r$, h is a function of r.

From the physical interpretation of the quantities involved, we see that there is a one-to-one correspondence between h and r; and h is an increasing function of r.

Let the relation between h and r be written $r = R(h)$. Then the probability that h lies between two specified values h_1 and h_2, $h_1 < h_2$, is given by

$$p(h)]_{h_1}^{h_2} = \int_{r_1}^{r_2} e^{-r}dr = e^{-r_1} - e^{-r_2}$$

where $r_1 = R(h_1)$ and $r_2 = R(h_2)$. In particular, the probability that $h \geq h_0$ is

$$p(h)]_{h_0}^{\infty} = \int_{r_0}^{\infty} e^{-r}dr = e^{-r_0}$$

where $r_0 = R(h_0)$.

We now discuss an example. For purposes of illustration we shall indicate here the statistical analysis of the example described in reference 1. In that example we considered a rocket whose space displacement equations are $x = 1{,}500\ (1 - e^{-0.1t})$ and $y = 1{,}000\ (1 - e^{-0.1t}) - 50t$, in which x and y are in miles and t is in hours. We assumed that the only stress relevant to the durability of the rocket is that induced by the atmospheric pressure. We also assumed that the relation between atmospheric pressure and elevation is given by $p = 29e^{-0.5y}$, where y is in miles and p is in inches of mercury.

Experimental studies on the durability of components of a ram-jet engine indicate that the plot of the logarithm of the ambient air pressure against hours to failure is sensibly rectilinear. On this account, for illustrative purposes, we assumed the relation between static life and pressure to be given by the equation

$$L = \ln 40 - \ln p$$

where p is in inches of mercury and L is in hours.

For this example the equation for the dynamic life takes the form

$$\int_0^h \frac{dt}{500.322 - 25t - 500\,e^{-0.1t}} = r$$

To find the probability that the rocket will function for at least 8 hours, we compute—e.g., by Simpson's method—the value of r corresponding to $h = 8$. We find r to be 2.20, approximately. Thus the above-mentioned probability is given by $e^{-2.2}$ or 11.1 per cent.

(II) Variability in Static Life Function and Stress Function

We now will consider, in addition to the variability in the static life function, a variability in the stress time function. We shall take the function $x = F(t)$ as giving the average value of the stress at the time t. As an approximation, we now make the assumption that the ratio

$$s = \frac{\text{actual value of the stress at time } t}{\text{average value of the stress at time } t}$$

is a constant throughout the stress course—i.e., it is independent of the time t.

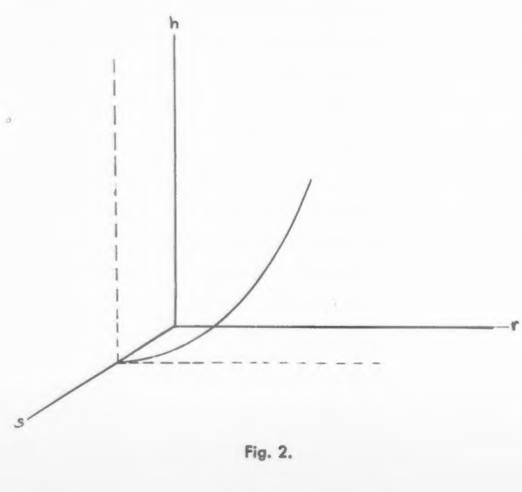

Fig. 2.

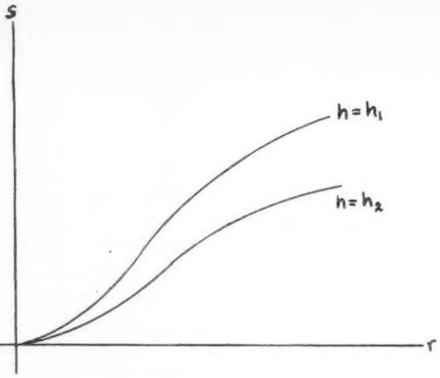

Fig. 3.

The basic equation now becomes

$$\int_0^h \frac{dt}{rf[sF(t)]} = 1 \quad \text{or} \quad \int_0^h \frac{dt}{f[sF(t)]} = r$$

The dynamic life h is now a function of two statistically independent variables r and s. We may thus write $h = H(r, s)$.

Consider the surface represented by $h = H(r, s)$. From the physical interpretation of the quantities involved, we see that

(1) For a fixed s, h is an increasing function of r, and moreover, as r approaches zero, h also approaches zero.

(2) For a fixed r, h is a decreasing function of s, and moreover (a) as s increases indefinitely, h approaches zero, and (b) as s approaches zero, h increases indefinitely.

The sections parallel to the sh plane are thus seen to have the general shape of the rectangular hyperbolas $sh = R(r)$, where $R(r)$ is a constant for each value of r (see Fig. 1).

The sections parallel to the rh plane are monotonically increasing curves which intercept the s-axis (see Fig. 2). Thus $R(r)$ is an increasing function of r. Moreover $R(0) = 0$. The surface $h = H(r, s)$ has the general shape of the surface $sh = R(r)$ where s, h, and r are the variables.

Consider now the sections parallel to the rs plane. When such sections are projected on the rs plane, they have the general shape of the curves $sh_1 = R(r)$ where h_1 is a constant. Each such curve passes through the origin. Moreover, if $h_1 \neq h_2$, the two curves $sh_1 = R(r)$ and $sh_2 = R(r)$ have no other common point than the origin. When $h_1 < h_2$, the two curves have the general shape indicated in Fig. 3.

We now propose to obtain the distribution of the dynamic life h in terms of the distributions of r and s.

We make the assumption that the ratio s is approximately normally distributed. It seems quite plausible to assume that the mean $\bar{s}$ may be taken as 1, and that the standard deviation σ is a small fraction of 1. Thus the probability density function of s is given, approximately, by

Table I.

s =	0.4	0.6	0.8	1	1.2	1.4	1.6	1.8
r =	1.06	1.36	1.72	2.20	3.46	3.92	5.78	10.08

$$(1/\sqrt{2\pi}\sigma)e^{-(s-1)^2/2\sigma^2}$$

As r and s are statistically independent, the joint distribution of r and s may be written

$$(1/\sqrt{2\pi}\sigma)e^{-[(s-1)^2/2\sigma^2]-r}$$

Then the probability that h lies between h_1 and h_2, $h_1 < h_2$ is given by

$$\frac{1}{\sqrt{2\pi}\sigma}\int_R\int e^{-[(s-1)^2/2\sigma^2]-r}\,dr\,ds$$

where R is the region bounded by the curves represented by $sh_1 = R(r)$ and $sh_2 = R(r)$. Thus R is the region indicated by the cross-hatched area in Fig. 3.

In particular, the probability that $h \geq h_0$ is given by

$$\frac{1}{\sqrt{2\pi}\sigma}\int_{R_0}\int e^{-[(s-1)^2/2\sigma^2]-r}\,dr\,ds$$

where R_0 is the total region (in the first quadrant) "outside" of the curve $sh_0 = R(r)$—i.e., the region indicated in the cross-hatched area in Fig. 4.

An Example

We shall now apply this method to the example described earlier. Assume here that the ratio s is distributed normally with mean = 1 and standard deviation $\sigma = 1/4$.

The equation for the dynamic life takes the form

$$\int_0^h \frac{dt}{500.322 - 25t - 500\,e^{-0.1t} - \ln s} = r$$

For $h = 8$ hours, we have the numerical results shown in Table 1.

From this, one obtains as the section of the surface $h = H(r, s)$ by the plane $h = 8$, the graph plotted in Fig. 5. Let this relation be indicated by $r = g(s)$.

The probability that the rocket will function for at least 8 hours is given by

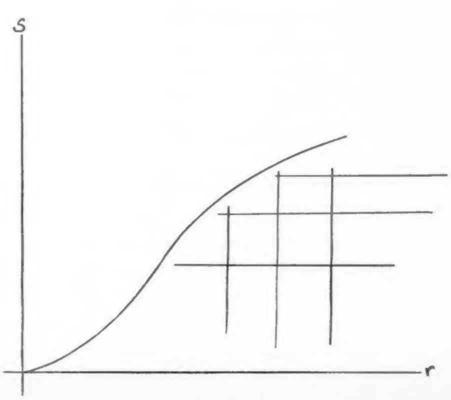

Fig. 4.

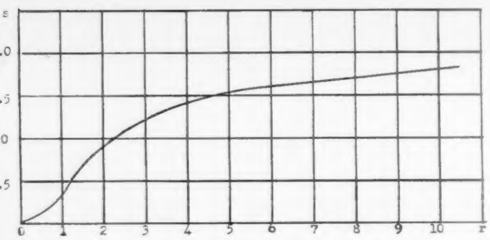

Fig. 5.

$$1 - \frac{1}{\sqrt{2\pi}\,\sigma}\int_R\int e^{-r} e^{-(s-1)^2/2\sigma^2}\,dr\,ds$$

where R is the cross-hatched area.

$$-\frac{1}{\sqrt{2\pi}\,\sigma}\, e^{-(s-1)^2/2\sigma^2}\, e^{-r}\Big]_0^{g(s)} =$$

$$-\frac{1}{\sqrt{2\pi}\,\sigma}\, e^{-(s-1)^2/2\sigma^2}\,(e^{-g(s)} - 1)$$

Hence the above probability is

$$1 - \frac{1}{\sqrt{2\pi}\,\sigma}\int_0^\infty e^{-(s-1)^2/2\sigma^2}\,ds + \frac{1}{\sqrt{2\pi}\,\sigma}\int_0^\infty e^{-[(s-1)^2/2\sigma^2]-g(s)}\,ds$$

From tables we find that the second term is 1, correct to five decimal places. By Simpson's rule, one finds that the third term is approximately 0.1134. Hence the probability sought is approximately 11.34 per cent.

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The Discus Body *(Continued from page 56)*

Apart from aerodynamic features, the advantages in the stress characteristics must be pointed out. The better load distribution reduces the total structure weight to approximately 17 to 20 per cent of the gross weight, whereas the conventional wing-fuselage design requires 25 to 30 per cent.

The high-scale production of a circular body may be simplified and the labor hours reduced, resulting in lower price or more airplanes for defense expense.

A discus utility vehicle is able to speed up the present spot-to-spot traffic by traveling five times the block speed made on the road today and may improve the service of today's commercial airliners.

The tactical application of VTOL vehicles increases Army mobility to a new stage in mechanized warfare. As motorcars once replaced horses, a team of VTOL battle crafts can now antiquate motorcars. These vehicles would actually include the third dimension in the combat operation of the Army.

The discus shape indicates equally good abilities to operate in air density, in rarefied region, and in empty space.

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Confinement of Plasma by Standing Electromagnetic Wave. Vincent Cushing and M. S. Sodha. *Phys. Fluids*, Sept.-Oct., 1959, pp. 494–498. Analysis similar to that carried out for a $TM_{0,1}$ mode, but with the assumptions limiting the applicability of present theories examined in detail.

Thermodynamics of Electrically Conducting Fluids. Boa-Teh Chu. (*Brown U. Div. Eng. Rep.*, Dec., 1957.) *Phys. Fluid*, Sept.-Oct., 1959, pp. 473–484. 12 refs. USAF-supported research.

Magnetohydrodynamic Wave of Finite Amplitude at Magnetic Prandtl Number 1. Hidenori Hasimoto. *Phys. Fluids*, Sept.-Oct., 1959, pp. 575, 576.

Two Dimensional Hypersonic Flow of an Ideal Gas with Infinite Electric Conductivity Past a Two-Dimensional Magnetic Dipole. Takeo Sakurai. *J. Aero/Space Sci.*, Dec., 1959, pp. 841, 842. Study of a frozen region as a practical means of thermal protection during re-entry. The frozen region is assumed to occur in a circle with its center at the dipole, and the outer flow is the shock layer behind a strong circular shock wave. The analysis is performed in the neighborhood of the stagnation streamline by applying the Hida-Lighthill method to the outer flow and the usual theory of static magnetic field to the frozen region.

Equations of the Electrodeless Ring Discharge and Their Solution for the Breakdown Criterion. H. U. Eckert. *Convair Sci. Res. Lab. RR 5*, Aug. 1959. 33 pp. 23 refs. Derivation of dif-

One of a series

Resolving the driver-car-road complex

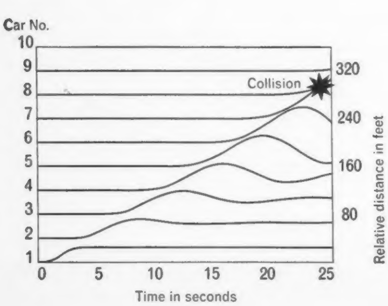
The manner in which vehicles follow each other on a highway is a current subject of theoretical investigation at the General Motors Research Laboratories. These studies in traffic dynamics, coupled with controlled experiments, are leading to new "follow-the-leader" models of vehicle interaction.

For example, conditions have been derived for the stability of a chain of moving vehicles when the velocity of the lead car suddenly changes — a type of perturbation that has caused multiple collisions on modern superhighways. Theoretical analysis shows that the motion of a chain of cars *can be stable* when a driver accelerates in proportion to the relative velocity between his car and the car ahead. The motion is always unstable when the acceleration is proportional only to the relative distance between cars. Experimentally, GM Research scientists found that a driver does react mainly to relative velocity rather than to relative distance, with a sensitivity of reaction that increases with decreasing distance.

Traffic dynamics research such as this is adding to our understanding of intricate traffic problems — what causes them, how they can best be resolved. The study is an example of the ways GM Research works to make transportation of the future more efficient and safe.

General Motors Research Laboratories

Warren, Michigan



Relative positions of 10 hypothetical cars after lead car goes through maneuver. Amplitude of instability increases, resulting in a collision between 7th and 8th cars.

ferential equations for the distributions of magnetic field, induced electric field, and conductivity for the case of a long cylindrical tube in which a discharge is maintained at medium pressure and moderate input by induction from a surrounding solenoid.

A Theory of Electromagnetically Driven Shock Waves. J. K. Wright and M. C. Black. *J. Fluid Mech.*, Aug., 1959, pp. 289–301. Presentation of a general theory for devices where strong shock waves are generated in gases by electromagnetic forces on current-carrying gas particles.

Torsional Oscillations of a Plane in a Viscous Fluid. S. Rosenblat. *J. Fluid Mech.*, Aug., 1959, pp. 206–220. Analysis of secondary flows which arise when an infinite plane lamina performs small torsional oscillations in a fluid otherwise at rest.

Collisionless Plasma Shock. S. A. Colgate. *Phys. Fluids*, Sept.-Oct., 1959, pp. 485–493. 10 refs. Study concluding that the shock transition takes place through the mechanism of a strong electric field produced by charge separation. The pressure in the shock plasma is due primarily to a very high electron temperature. The entropy increase occurs by Landau damping of the coherent electron oscillation.

Steady State Flow of Detonating Gas Around a Cone. S. S. Kvashnina and G. G. Chernyi. (*Prikl. Mat. i Mekh.*, Jan.-Feb., 1959, pp. 182–186.) *PMM—Appl. Math. & Mech.*, No. 1, 1959, pp. 252–259. 11 refs. Translation.

Selfsimilar Motions of Gas with Shock Waves, Spreading with Constant Speed Into Gas at Rest. G. L. Grozdovskii, A. N. Diukalov, V. V. Tokarev, and A. I. Tolstykh. (*Prikl. Mat. i Mekh.*, Jan.-Feb., 1959, pp. 198–200.) *PMM—Appl. Math. & Mech.*, No. 1, 1959, pp. 281–286. Translation. Analysis of shock waves propagating with constant speed to determine the variations of speed, density, and pressure.

On Nonlinear Reflection of Weak Shock Waves. O. S. Ryzhov and S. A. Khristianovich. (*Prikl. Mat. i Mekh.*, Sept.-Oct., 1958, pp. 586–599.) *PMM—Appl. Math. & Mech.*, No. 5, 1958, pp. 826–843. Translation. Study of certain physical conditions which permit significant simplications to be made in the equations of gas dynamics describing the nonsteady flows with small but sharp changes of the parameters of the medium. The mathematical approximations are based on the fact that the pressure variations in the stream take place in a small region adjacent to the shock wave front.

The Hypothesis of Localness in the Turbulent Motion of a Viscous Fluid. L. G. Loitsianskii. (*Prikl. Mat. i Mekh.*, Sept.-Oct., 1958, pp. 600–611.) *PMM—Appl. Math. & Mech.*, No. 5, 1958, pp. 844–859. Translation. Extension to the whole field of turbulent motion, where there is an interaction of molecular and molar processes, of the hypothesis of localness for the mechanism of turbulent mixing and for the Reynolds analogy between the transport of momentum and heat.

A Simple Method for Determining Turbulent Skin Friction from Velocity Profiles. P. Bradshaw. *J. Aero/Space Sci.*, Dec., 1959, p. 841.

Heat Transfer and Friction in Turbulent Vortex Flow. Frank Kreith and David Margolis. *Appl. Sci. Res., Sect. A*, No. 6, 1959, pp. 457–473. 25 refs. Results of measurements of the heat-transfer and friction coefficients for air and water flowing through a pipe with several types of inserts designed to induce a swirl in the flow.

Internal Flow

On the Nature of Stall. S. J. Kline. (*ASME Annual Meeting, New York, Nov. 30–Dec. 5, 1958, Paper 58–A-170.*) *ASME Trans., Ser. D - BE*, Sept., 1959, pp. 305–319; Discussion, pp. 319, 320. 37 refs. AFOSR-sponsored review of physical data available on the problem of stall, with special emphasis on systematic visual data showing flow patterns in passages as a function of geometrical parameters. These data lead to a view of stall as a spectrum including three or possibly four major types of flow patterns involving both transient and steady elements.

Loss and Stall Analysis of Compressor Cascades. Seymour Lieblein. (*ASME Annual Meeting, New York, Nov. 30–Dec. 5, 1958, Paper 58–A-91.*) *ASME Trans., Ser. D - BE*, Sept., 1959, pp. 387–397; Discussion, pp. 397–400. 16 refs. Derivation of a simple equation from boundary-layer theory in conjunction with simplifying approximations, which expresses the wake momentum thickness as a primary function of the suction-surface diffusion ratio of conventional low-speed cascade blades.

An Analysis of Axial Compressor Cascade Aerodynamics. I—Potential Flow Analysis with Complete Solutions for Symmetrically Cambered Airfoil Families. II—Comparison of Potential Flow Results with Experimental Data. G. L. Mellor. (*ASME Annual Meeting, New York, Nov. 30–Dec. 5, 1958, Papers 58–A-83; 58–A-84.*) *ASME Trans., Ser. D - BE*, Sept., 1959, pp. 362–386. 23 refs.

Systematic Two-Dimensional Cascade Tests of NACA 65-Series Compressor Blades at Low Speeds. Appendix A—Calculation of Blade Force Coefficients. Appendix B—Carpet-Plotting Technique. J. C. Emery, L. J. Herrig, J. R. Erwin, and A. R. Felix. *U.S., NACA Rep. 1368*, 1958. 85 pp. Supt. of Doc., Wash., $0.70.

Modulation Phenomena in Stall Propagation. J. A. Rockett. (*ASME Annual Meeting, New York, Nov. 30–Dec. 5, 1958, Paper 58–A-152.*) *ASME Trans., Ser. D - BE*, Sept., 1959, pp. 417–425. Description of stall propagation in a single-stage research compressor, including a study of different stall patterns and their transitions.

Der Einfluss aufgezwungener Energiegradienten auf die Strömung in Turbomaschinen. M. H. Vavra. *Forschung Gebiete Ing., Ausg. A*, No. 3, 1959, pp. 79–91. In German. Study of the influence of imposed energy gradients on the flow in turbomachines.

Messungen und Grenzschichtbeobachtungen an affin verdickten Gebläseprofilen in Abhängigkeit von der Reynoldszahl. Günther Muesmann. *ZFW*, Sept., 1959, pp. 253–264. 16 refs. In German. Description of measurements on four compressor blade and propeller sections for Reynolds Numbers between 17,000 and 400,000. Boundary-layer effects and separation phenomena observed at low Reynolds Numbers were studied, using naphthalene evaporation and stethoscope technique, as well as three-dimensional wake measurements.

Ob Odnoi Skheme Vysokonapornogo Tsentrobezhnogo Kompressora. V. A. Strunkin. *MVO SSSR VUZ Izv. Av. Tekh.*, Jan.–Mar., 1959, pp. 105–110. In Russian. Evaluation of the design of a high-pressure centrifugal compressor and theoretical analysis of its performance.

Optimum Design of Straight-Walled Diffusers. S. J. Kline, D. E. Abbott, and R. W. Fox. (*ASME Annual Meeting, New York, Nov. 30–Dec. 5, 1958, Paper 58–A-137.*) *ASME Trans., Ser. D - BE*, Sept., 1959, pp. 321–329; Discussion, pp. 329–331. 40 refs. AFOSR-sponsored definition of the four common optimum problems in diffuser design and their location in relation to the overall flow regimes in terms of geometrical parameters for straight-walled units. Using a transformation of variables between conical and two-dimensional geometries, all available data for optimum recovery at constant ratio of wall length to throat width are correlated by a single straight line.

Some Measurements of Boundary-Layer Growth in a Two-Dimensional Diffuser. J. F. Norbury. (*ASME Annual Meeting, New York, Nov. 30–Dec. 5, 1958, Paper 58—A-196.*) *ASME Trans., Ser. D - BE*, Sept., 1959, pp. 285–294; Discussion, pp. 294–296. 28 refs. Discussion of low-speed experiments carried out in a diffuser with a square throat and an area ratio of two to one. The static pressure distribution, velocity contours at throat and outlet, and boundary-layer growth along the four wall centerlines are measured, and the visual flow is studied using tufts and smoke filaments.

Supersonic Flow in a Tube with Longitudinal Slots. G. P. Wachtell and S. P. Carfagno. *Phys. Fluids*, Sept.-Oct., 1959, pp. 521–526. Army-supported derivation of a differential equation for the pressure along the axis of a longitudinally slotted tube through which there is supersonic gas flow, for the general case in which both the tube cross section and the slot width vary with axial position.

The Total-Pressure Recovery and Drag Characteristics of Several Auxiliary Inlets at Transonic Speeds. J. S. Dennard. *U.S., NASA Memo. 12-21-58L*, Mar., 1959. 59 pp. Experimental investigation of several flush- and scoop-type auxiliary inlets at a Mach Number range of 0.55 to 1.3 in order to determine their transonic pressure recovery and drag characteristics. An inlet incorporating a boundary-layer bypass on each side of the ramp is shown to give superior drag performance over all other inlets and over most of the Mach Number range tested.

Static and Dynamic Control Characteristics of Flapper-Nozzle Valves. Tsun-Ying Feng. (*ASME Annual Meeting, New York, Nov. 30–Dec. 5, 1958, Paper 58—A-160.*) *ASME Trans., Ser. D - BE*, Sept., 1959, pp. 275–282; Discussion, pp. 282–284. Comparison of theoretical and experimental results for the basic characteristics of flapper-nozzle hydraulic control valves. The correlation is found to be good.

The Exact Solution of Borda's Mouthpiece in Two Dimensions. Ch. A. Hachemeister. *Quart. Appl. Math.*, Oct., 1959, pp. 299–304. Application of conformal mapping techniques to a finite mouthpiece to determine the coefficient of contraction and maximum surface speed.

K Raschetu Sopel. I. M. Iur'ev. *AN SSSR Otd. Tekh. Nauk Izv. Mekh. i Mashinostr.*, July-Aug., 1959, pp. 140, 141. In Russian. Derivation of an exact solution for the nonlinear equation representing the main part of the exact equation for the three-dimensional motion of gas over the Mach Number range of $O < M < 1.7$. The results are applied to the calculation of nozzles.

Raschet Kharakteristik Osevykh Prednasosov. I. V. Miroliubov. *MVO SSSR VUZ Izv. Av. Tekh.*, Jan.-Mar., 1959, pp. 81–88. In Russian. Calculation of the characteristics of auxiliary axial pumps used to improve the anticavitational properties of the main system.

Performance

The Effect of Scale on Fine Sprays Produced by Large Air-Blast Atomizers. L. D. Wigg. *Gt. Brit., NGTE Rep. R.236*, July, 1959. 27 pp. 12 refs. Test results on atomizers capable of handling large flows (0.1 lb./sec. or greater) while producing fine sprays (mass median diameter less than 50 microns).

Optimum Airplane Flight Paths. Placido Cicala. (*Torino Accad. Sci., Atti*, May, 1955, pp. 350–358.) *U.S., NASA TT F-4*, Oct., 1959. 13 pp. Translation.

An Investigation of Optimal Zoom Climb Techniques. H. J. Kelley. (*IAS 27th Annual Meeting, New York, Jan. 26–29, 1959, Rep. 59-16.*) *J. Aero/Space Sci.*, Dec., 1959, pp. 794–802, 824. 23 refs. USAF-sponsored research.

Stability & Control

Low-Subsonic Measurements of the Static and Oscillatory Lateral Stability Derivatives of a Sweptback-Wing Airplane Configuration at Angles of Attack from -10° to 90°. D. E. Hewes. *U.S., NASA Memo. 5-20-59L*, June, 1959. 36 pp. Wind-tunnel investigation of the basic stability and control characteristics in the high angle-of-attack range of an airplane. It is found that the configuration is directionally unstable for all angles of attack above about 15° but maintains positive effective dihedral, control effectiveness, and damping in roll and yaw over most of the angle-of-attack range tested.

Preliminary Note on the Effect of Inertia Cross-Coupling on Aircraft Response in Rolling Manoeuvres. Appendix A—Autorotational Rates of Roll of an Aircraft with Inertia-Coupling. Appendix B—Control Manoeuvres Required to Roll with $\Delta\alpha = 0$ and $\beta = 0$. Appendix C—Numerical Example for Ideal Control Coordination in Rolling Manoeuvres. Appendix D—Aircraft Motion with Constant Rate of Roll. Appendix E—Aircraft Response to Instantaneously Applied p. Appendix F—Aircraft Response to a Square Wave Function p(t). W. J. G. Pinsker. *Gt. Brit., ARC CP 435* (Nov., 1955) 1959. 88 pp. BIS, New York, $2.25.

A Flight Investigation to Determine the Lateral Oscillatory Damping Acceptable for an Airplane in the Landing Approach. W. E. McNeill and R. F. Vomaske. *U.S., NASA Memo. 12-10-58A*, Feb., 1959. 33 pp. Analysis of the minimum satisfactory lateral oscillatory damping of aircraft in the landing approach for normal operation and for failure of stability-augmentation equipment, using a test airplane with variable lateral and directional stability. The effects of oscillatory period and bank-to-sideslip ratio on the opinion ratings of seven pilots are discussed.

A Flight Investigation of the Low-Speed Handling Qualities of a Tailless Delta-Wing Fighter Airplane. M. D. White and R. C. Innis. *U.S., NASA Memo. 4-15-59A*, May, 1959. 33 pp. Study of factors that adversely affect the landing-approach characteristics of an F4D-1 aircraft.

Wings & Airfoils

Transonic Flow Over Two-Dimensional Round-Nosed Aerofoils. D. G. Randall. *Gt. Brit., ARC CP 456* (Sept., 1958) 1959. 29 pp. 14 refs. BIS, New York, $0.72. Extension of the Spreiter and Alksne technique for determining the pressure distribution over a two-dimensional sharp nosed airfoil moving at transonic speed to the case of a round-nosed airfoil at incidence.

Boundary-Layer Interaction on a Yawed Infinite Wing in Hypersonic Flow. R. J. Whalen. *J. Aero/Space Sci.*, Dec., 1959, pp. 839–841.

A Family of Camber Lines for Subsonic Applications (A Modified Form of the N.A.C.A. Family with Uniform Loading Over the Forward Part and Linear Loading Over the Rear Part). H. B. Squire. *Gt. Brit., ARC CP 437* (Apr. 17, 1958) 1959. 8 pp. BIS, New York, $0.27.

The Pressure Distribution on Dihedral Wings at Supersonic Speed. Lu Ting. (*Polytech. Inst. Bklyn., Dept. Aero. Eng. & Appl. Mech., PIBAL Rep. 397*, Jan., 1958.) *J. Fluid Mech.*, Aug., 1959, pp. 302–312. 11 refs.

An Analysis of Pressure Studies and Experimental and Theoretical Downwash and Sidewash Behind Five Pointed Tip Wings at Supersonic Speeds. Appendix A—Details of Conical Flow Method. Appendix B—Details of Horseshoe Vortex Method. Appendix C—Details of Single-Bent-Line-Vortex Method. Appendix E—Details of the Method for the Combination of the Conical-Flow and the Infinite-Line-Vortex Theories. W. B. Boatright. *U.S., NACA Rep. 1380*, 1958. 57 pp. 29 refs. Supt. of Doc., Wash., $0.55.

Measurements of the Velocity at the Vortex Centre on an A.R.I Delta Wing by Means of Smoke Observations. A. P. Cox. *Gt. Brit., RAE TN Aero. 2634*, June, 1959. 8 pp. Investigation showing that the velocity at the center is at least 40 per cent higher than the free stream. Near the trailing edge, the velocity at the center decreases rapidly to approximately free-stream velocity.

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INTERNATIONAL AERONAUTICAL ABSTRACTS

A Review of Worldwide Scientific and Technical Literature

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ACOUSTICS, SOUND, NOISE

AN EXPERIMENTAL INVESTIGATION OF THE NOISE GENERATED BY THE TURBULENT FLOW AROUND A ROTATING CYLINDER. L. N. Wilson. UTIA Rep. 57, Apr., 1959. 73 pp. 19 refs. USAF-supported study of the near and far field noise from the turbulent boundary layer developed on a rotating cylinder, using both smooth and artificially roughened surfaces. The mean square pressure followed a U_o^4 law in the near field and approximated a U_o^6 law, as did the acoustic power, in the far field. The U_o^6 law suggests that the dominant radiators are of a dipole type. Drag calculations from hot wire measurements allowed an estimate of the efficiency of the far field radiation, resulting in an efficiency of about ten times that for the quadrupole radiation from a jet at a Mach Number of 0.228. The measured noise power from the boundary layer over a rigid wall appears to be relatively small in any practical application to the noise in aircraft.

AERODYNAMICS, FLUID MECHANICS

Aerothermochemistry, Dissociation, Ablation

LIEPMANN'S HEAT TRANSFER METHOD IN AEROTHERMOCHEMISTRY. Robert Goulard. Purdue U. Sch. Aero. Eng. Rep. A-59-5, Aug., 1959. 9 pp. Application of an integral method proposed by Liepmann to present, in simple form, some physical aspects of the boundary layer problem. Because of the physical character of this method, proper simplifications can be made to otherwise complex mathematical propositions, and lead to a variety of results with good approximation. Examples shown include chemical equilibrium flow, chemical relaxation in the stream, and the influence of the magnetic field on heat transfer at stagnation.

TEMPERATURE PROFILES IN A FINITE SOLID WITH MOVING BOUNDARY. C. F. Dewey, Jr., S. I. Schlesinger, and Lawrence Sashkin. J. Aero/Space Sci., Jan., 1960, pp. 59-64. 19 refs. USAF-supported presentation of a numerical solution to the transient heat conduction equation for a cylinder of finite thickness with one moving boundary. The implicit method of solution is developed with conductivity as an arbitrary function of temperature. Application is made to a sample case of re-entry heating encountered by aerodynamic bodies, with erosion by sublimation and combustion occurring at the body surface.

EFFECTS OF AIR DISSOCIATION AND IONIZATION AT HYPERSONIC SPEED. Gianni Jarre. Torino Polytech. Inst. Appl. Mech. Lab. TN 14 (AFOSR TR 59-119), July, 1959. 35 pp. Analysis considering the ionization and dissociation either behind a strong normal shock wave or at the wall of an adiabatic flat plate. The state of chemical equilibrium is studied with the aid of a thermodynamic chart of atmospheric air, using simplified schemes of real flows. The dynamic problem of relaxation is also investigated, but only in the field of oxygen dissociation. Simplified methods for calculating the length of the relaxation processes are developed, discussed, and applied to numerical examples.

RATE OF HEAT-TRANSFER NEAR THE STAGNATION POINT OF A BLUNT BODY OF REVOLUTION, IN THE PRESENCE OF A MAGNETIC FIELD. R. X. Meyer. Space Tech. Lab. PRL GM TR 0127-00016, Mar. 14, 1958. 59 pp. 11 refs. Extension of the previously obtained similarity solution for the two-dimensional viscous stagnation-point flow in the presence of a magnetic field to the rotationally symmetric case. Joule heating and the heat generated by viscous dissipation are also taken into account. A new formulation for the boundary conditions is found, leading to an exact solution in terms of ordinary differential equations which, in turn, are integrated numerically. The typical orders of magnitude of the parameters are then discussed for the case of the re-entry into the atmosphere of a satellite or a ballistic missile. It is found that these orders of magnitude are such that a boundary layer approximation of the magnetohydrodynamic problem can be made. The singular perturbation corresponding to this approximation is carried out,and the Nusselt Number characterizing the rate of heat transfer to the body is computed as a function of the magnetic field strength.

A STUDY OF HYPERSONIC ABLATION. S. M. Scala. G-E MSVD AL TIS R59SD438, Sept. 30, 1959. 62 pp. 59 refs. Theoretical determination of the aerothermochemical response of four different classes of materials to the severe heating encountered during the hypersonic re-entry of space vehicles. These materials include quartz-like refractories, graphite, thermosetting plastics, and thermoplastics. It is concluded that the effective heat of ablation of each material depends critically on the enthalpy level of the flight environment and increases with increasing flight speed; the effect of an increase in stagnation pressure is to promote a decrease in the effective heat of ablation; and the specific area of greatest uncertainty is in the kinetics of condensed phase heterogeneous reactions.

A THEORY OF ABLATION OF GLASSY MATERIALS FOR LAMINAR AND TURBULENT HEATING. Henry Hidalgo. Avco Everett Res. Lab. RR 62 (AFBMD TN 59-13), June, 1959. 27 pp. 16 refs. Reduction of the steady-state equations of motion for a thin layer of an incompressible, glassy material on the surface of an ablating and radiating blunt body to a first-order ordinary differential equation which is integrated numerically. The solution is coupled with the solution of the air boundary layer for both laminar and turbulent heat transfer with or without mass vaporization of the ablating material. The distribution of the effective energy of ablation around the body is thus obtained for a cone cylinder with a hemispherical cap which re-enters the atmosphere at hypersonic speeds and has quartz as the ablating material.

ON ABLATING HEAT SHIELDS FOR SATELLITE RECOVERY. Steven Georgiev, Henry Hidalgo, and M. C. Adams. Avco Everett Res. Lab. RR 65 (AFBMD TR 59-7), July, 1959. 28 pp. 16 refs. Presentation of a simple theory for the energy absorbed per unit mass of ablated material. Experimental results, obtained in an air arc wind tunnel under simulated re-entry conditions, are given for Teflon and Fiberglas, and a good agreement with theory is found. Insulation requirements for various types of heat shields are discussed, and it is shown that a low temperature ablating heat shield is superior to both the heat sink and radiating heat shields.

Aerothermodynamics

ON THE INFLUENCE OF VISCOSITY AND HEAT CONDUCTION ON THE GAS FLOW BEHIND A STRONG SHOCK WAVE. L. I. Sedov, M. P. Michailova, and G. G. Chernyi. (Moscow, Univ. Vestnik, No. 3, 1953, pp. 95-100.) Brown U. Div. Eng. Rep. (USAF WADC TN 59-349), Oct., 1959. 11 pp. Translation. Study of the case of a symmetric supersonic flow of gas past a body of revolution or a planar profile with the formation of a detached shock wave ahead of the body. The equations describing the flow behind to shock wave are given, assuming that the variation of viscous stresses and the heat flow is small when the coordinates change. From these equations, and from the condition of flow symmetry, the derivatives of the hydrodynamic quantities can be expressed through the values of these quantities themselves. The corrections to the values of the hydrodynamic quantities on the axis of symmetry behind a shock wave, which result from the effect of viscosity and heat conduction, are determined, in particular, for values of the stagnation temperature and stagnation pressure ratios behind and in front of the shock.

EXPERIMENTAL INVESTIGATION OF THE DOWNSTREAM INFLUENCE OF STAGNATION POINT MASS TRANSFER. P. A. Libby and R. J. Cresci. Polytech. Inst. Bklyn., Dept. Aero. Eng. & Appl. Mech., PIBAL Rep. 520 (USAF WADC TN 59-210), Sept., 1959. 44 pp. 20 refs. Presentation of experimental results on the downstream influence of localized mass transfer in the stagnation region of a blunt body under hypersonic flow conditions. The coolant is injected through a porous plug coaxial with the centerline of symmetry of the model. The tests were carried out in a Mach 6 wind tunnel with stagnation temperatures of approximately 1, 600°R. and with a stagnation pressure of approximately 600 psia. Four different gases were injected over a range of mass flows, and the heat transfer on the impermeable section was measured under isothermal wall conditions; for the higher rates of mass flow, adiabatic surface temperatures were also determined. The theoretical analysis of the boundary layer flow is investigated in order to establish the similarity parameters for the flow system. These parameters permit the extrapolation of the test results to other flow conditions, provided laminar flow prevails. Helium is found to be the most efficient coolant.

SOME PRACTICAL ASPECTS OF KINETIC HEATING CALCULATIONS. C. L. Bore. RAeS J., Nov., 1959, pp. 637-645. Analysis of the aerodynamic heat transfer relationship with the object of separating the effects of skin surface temperature from those effects which depend on prescribed sortie conditions. The equation governing transient heating for shell structures is then shown. From this, a step-by-step method of solution is derived. It is shown that this method can be applied easily to complicated structures with general modes of heat transfer between the various parts, and can deal simply with variations of heat transfer coefficient, heat capacity, and thermal emissivity.

O TECHENIIAKH S BOL'SHOI TEPLOPROVODNOST'IU. M. N. Kogan. AN SSSR Dokl., Sept. 21, 1959, pp. 488-490. In Russian. Study of certain characteristic types of flow occurring in the case of high heat conductivity. Equations are derived for the viscous boundary layer of thickness $\delta_\mu = L/\sqrt{Re}$ and the thermal boundary layer of thickness $\delta_K = L/\sqrt{Re}$; the temperature across the viscous layer is assumed to be constant and equal to wall temperature, and, in the thermal layer, the viscosity effect can be neglected. The boundary conditions are stated and the solution is used to calculate the velocity at the boundary of the viscous layer. The heat transfer to the wall is determined, taking into account the kinetic heating in the viscous layer. The temperature distribution in finite regions is described by means of the Laplace equation, assuming the heat transfer coefficient k = const; for infinite regions the convective transfer must be taken into account. The process for solving the case of an arbitrary body is briefly indicated, and it is pointed out that, in the case of supersonic flow, the turbulence occurs upstream of the body.

AN INVESTIGATION OF POROUS WALL COOLING. R. P. Bernicker. MIT NSL TR 393 (AFOSR TN 59-873), June, 1959. 59 pp. 10 refs. Development of equations describing the thermal exchange when a coolant is forced through a heated porous wall, and presentation of solutions on the basis of a simplified model consisting of identical cylindrical channels replacing the actual capillary-like passages. The solutions depend upon Reynolds and Prandtl Numbers, geometric parameters involving wall porosity and pore size, and Nusselt Number. Experiments are performed with one family of porous materials, and Nusselt Numbers are correlated in terms of Reynolds and Prandtl Numbers and porosity. Temperature distributions obtained indicate a very small difference between solid and coolant temperatures at the exit surface.

USE OF A THEORETICAL FLOW MODEL TO CORRELATE DATA FOR FILM COOLING OR HEATING AN ADIABATIC WALL BY TANGENTIAL INJECTION OF GASES OF DIFFERENT FLUID PROPERTIES. J. E. Hatch and S. S. Papell. US, NASA TN D-130, Nov., 1959. 43 pp. Derivation of an equation predicting the temperature of a film-cooled wall within 5% for a range of cooling effectiveness from approximately 0.2 to 1.0. A simple iteration process involving continuity can be used to solve the equation for the required coolant flow rate. Data covering a wide range of the variables (main gas stream velocity and temperature, velocity ratio, and coolant slot height) are used in the correlation. Both helium and air are used as the coolant gas.

SUBLIMATION OF A HEMISPHERE IN SUPERSONIC FLOW. Robert Weiss. MIT NSL TR 391 (AFOSR TN 59-870), July, 1959. 61 pp. 38 refs. Investigation of the heat transfer rates to several subliming bodies of hemispherical shape, covering tests at a Mach Number of 3.5 with solid carbon-dioxide, naphtalene, and camphor. Additional tests with camphor models determined the effect of Reynolds Number on the heat transfer rate. It was found that heat transfer was reduced in proportion to the mass-injection rate and a greater reduction was effected with a lesser weight material, and that increasing Reynolds Number also produced a lower level of heat transfer coefficient. The bodies tended to assume a conical shape - a phenomenon more noticeable with increasing Reynolds Number; only one model appeared to have reached a state of equilibrium. The investigation indicated both the feasibility of conducting an experiment of this nature and the applicability of subliming bodies both in reducing and absorbing aerodynamic heating.

Boundary Layer

MEASUREMENTS OF THE EFFECT OF SURFACE COOLING ON BOUNDARY LAYER TRANSITION ON A 15° CONE. II - TESTS AT M = 3 AND M = 4 IN THE 5 in. x 5 in. No. 5 WIND TUNNEL AT R.A.E. FARNBOROUGH. J. G. Woodley. Gt. Brit., RAE TN Aero.2628, June, 1959. 37 pp. 15 refs. Results of tests on a steel cone with an included angle of 15° showing that the increase in transition Reynolds Number with surface cooling at zero incidence is greater at a local Mach Number of 2.93 than at 3.48. When the cone was set at an incidence of +2°, transition on the windward side moved aft with cooling at the lower Mach Number at approximately the same rate as was found in the zero incidence tests. However, at both Mach Numbers, little movement could be seen on the leeward generator.

STABILE FORMEN UND ÜBERGANGSERSCHEINUNGEN DER FLACHWASSERSTRÖMUNG AUF EINER SCHWACH GENEIGTEN EBENEN PLATTE. D. Huhnt. DVL Bericht No. 92, July, 1959. 62 pp. 11 refs. Westdeutscher Verlag, Köln & Opladen. In German. Investigation of the laminar-turbulent transition process observed on slightly inclined flat plates placed in shallow water. Results indicate that one state of flow can be represented by three flow parameters; only two parameters are necessary if the kinetic viscosity, surface stress, and thickness are assumed constant. The functions limiting the four observed stability regions are measured and the critical parameter functions are derived. One of these functions may be transformed into a critical Reynolds Number which separates the domains of growth and decay of turbulence. The investigated steady forms of flow and the transition phenomena are described, and the measured critical dimensionless functions are plotted.

APPROXIMATE METHOD FOR INTEGRATING THE EQUATIONS OF A LAMINAR BOUNDARY LAYER IN AN INCOMPRESSIBLE GAS IN THE PRESENCE OF HEAT TRANSFER. M. B. Skopets. Sov. Phys. - Tech. Phys., Apr., 1959, pp. 411-419. Translation. Solution based on a system of equations that are the successive moments (including the zeroth moment) of the equation of the boundary layer. This solution represents an extension of the solution of the hydrodynamic problem obtained by Loitsyanskii to the case of the thermal problem.

Flow of Fluids

TWO-DIMENSIONAL HYDRODYNAMIC CALCULATIONS. F. H. Harlow, D. O. Dickman, D. E.

Harris, Jr., and R. E. Martin. U. Calif. LASL Rep. LA-2301, Sept., 1959. 97 pp. 14 refs. Extension of a previously developed method for solving two-dimensional hydrodynamic problems. The calculation procedure is described in detail and illustrated on problems involving cartesian coordinates in a rigid rectangular box, other boundary conditions in cartesian coordinates, generalized problems in cartesian coordinates, and two-dimensional calculations in cylindrical coordinates. The limitations of the method are evaluated. Covered are such aspects as the shock-wave refraction with corner effects, shock passage through a discontinuously enlarged channel, interaction of a shock with perturbed interface, Taylor instability, and viscous flow calculations.

THE FLOW OF A VISCOUS FLUID PAST A TRIANGULAR CYLINDER. Mitutosi Kawaguti. Phys. Soc. Japan J., Oct., 1959, pp. 1,425-1,431. 12 refs. Analysis of viscous flow using Imai's method of solving Oseen's equations by expressing lift and drag as power series in the Reynolds Number (Re). The expression for the velocity in the flow field near the triangular cylinder is obtained correct to the order of Re^2, and those for the frictional, pressure, and total drag to the order of Re. The drag of the triangular cylinder at high Reynolds Numbers is estimated by using Imai's new theory of drag and is compared with Asaka and Ôshima's experimental results.

THE "NEWTONIAN" THEORY OF HYPERSONIC FLOW FOR ANY THREE-DIMENSIONAL BODY. N. C. Freeman. Gt. Brit., ARC CP 439, 1959. 21 pp. BIS, New York, $0.63. Extension of the Newtonian theory of hypersonic flow ($M = \infty$, $\gamma \rightarrow 1$) to flow past any three-dimensional body shape. Mathematical complexity limits the results obtained to those for slightly yawed axially symmetric bodies and, in particular, the cone is considered in detail. Pressure distribution and shock shape are obtained to a first approximation in $(\gamma - 1) / (\gamma + 1)$, and to a second approximation in sin δ, where δ is the angle of attack.

INVESTIGATION OF VARIATION IN BASE PRESSURE OVER THE REYNOLDS NUMBER RANGE IN WHICH WAKE TRANSITION OCCURS FOR TWO-DIMENSIONAL BODIES AT MACH NUMBERS FROM 1.95 TO 2.92. Vernon Van Hise. US, NASA TN D-167, Nov., 1959. 44 pp. 11 refs. Presentation of the results of a wind-tunnel study of two-dimensional base pressure throughout the Reynolds Number range of wake transition. The effects of model shape and fineness ratio are determined, and comparisons are made with the theory of Crocco and Lees. Results of wake disturbance tests and wake schlieren studies are also presented.

MEASUREMENT OF THE RECOVERY TEMPERATURE IN THE WAKE OF A CYLINDER AND OF A WEDGE AT MACH NUMBERS BETWEEN 0.5 AND 3. H. Thomann. Sweden, Flygtekniska Försöksanstalten, FFA Medd. 84, June, 1959. 21 pp. 14 refs. Test results showing that in subsonic flow the well-known vortex street appears behind the two bodies and the recovery factor in the middle of the base is between zero and 0.2. Temperature measurements on the side wall of the tunnel show the low temperatures to exist between two rows of vortices. A suppression of the vortex street by a splitter plate resulted in recovery factors of 0.8 to 0.9. The vortex street disappeared gradually in the transonic region and the recovery factor increased to 0.7-0.9 at the same time. For higher Mach Numbers (1.8 to 3) no vortex streets were found and the recovery factor was between 0.8 and 0.9. The relation between the vortex street and the low recovery factor is, therefore, obvious.

A MICROSCOPIC ANALYSIS OF MAGNETO-GAS-DYNAMICS. E. E. Covert. (3rd Biennial Gas Dynamics Symposium, Evanston, Aug. 24-26, 1959.) MIT NSL TR 395, 1959. 42 pp. 45 refs. Discussion of the kinetic theory approach to magnetogasdynamics. Several methods for considering interactions, in which the long range forces are of importance, are compared critically. The effects of the magnetic field on the particle interactions and their trajectories are shown to introduce anisotropies in magnetogasdynamics. The effects of these anisotropies are briefly discussed.

COLLISION FREE MAGNETOHYDRODYNAMIC SHOCK WAVE. A. Kantrowitz, R. M. Patrick, and H. E. Petschek. Avco Everett Res. Lab. RR 63, Aug., 1959. 12 pp. AFOSR-supported investigation in which it is assumed that the dissipation in a collision-free shock produces a random distribution of magnetohydrodynamic waves. These waves are then treated as the fundamental particles of the plasma. A rough kinetic theory is developed for estimating the heat conduction coefficient due to the waves. Using this heat conduction coefficient, the shock thickness is estimated to be about four times the characteristic ion Larmour radius. This prediction is in rough agreement with experimental results obtained in a MAST device.

THE DISINTEGRATION OF UNSTABLE SHOCK WAVES IN MAGNETOHYDRODYNAMICS. G. Ya. Lyubarski and R. V. Polovin. (Zhurnal Teoret. i Exper. Fiz., Apr., 1959, pp. 1,272-1,278.) Sov. Phys. - JETP, Oct., 1959, pp. 902-906. 15 refs. Translation. Study considering unstable magnetohydrodynamic shock waves. It is shown that such a wave must necessarily disintegrate into several waves among which there are fast and slow magnetoacoustic shock and similarity waves, Alfven discontinuities, and a contact discontinuity. It is significant that disintegration of the unstable shock wave is accompanied by an increase in entropy.

TWO-DIMENSIONAL STOKES FLOW OF AN ELECTRICALLY CONDUCTING FLUID IN A UNIFORM MAGNETIC FIELD. Hirowo Yosinobu and Tsunehiko Kakutani. Phys. Soc. Japan J., Oct., 1959, pp. 1,433-1,444. Analysis of a two-dimensional flow of a viscous, incompressible and electrically conducting fluid past a cylinder in a uniform magnetic field, using Stokes approximation. Detailed calculation is carried out for the flow past a circular cylinder in two cases: (1) in a parallel magnetic field and (2) in a transverse magnetic field. The expansion formulas for the drag per unit span of the cylinder are obtained in terms of the Hartmann Number in each case.

COMPRESSIBLE FLAT-PLATE BOUNDARY-LAYER FLOW WITH AN APPLIED MAGNETIC FIELD. W. B. Bush. J. Aero/Space Sci., Jan., 1960, pp. 49-58. 11 refs. USAF-supported development of the boundary-layer equations and solutions for a flat-plate in high-speed compressible air flow where equilibrium dissociation and ionization are assumed and where there is an applied magnetic field having its component normal to the plate proportional to $1/\sqrt{x}$. The results show that the skin friction and heat transfer at a given free-stream velocity decrease with increasing magnetic field strength, and the percentage reduction is constant along the length of the plate. They also exhibit the same hysteresis behavior as was first found in the case of magnetoaerodynamic Couette flow; however, for the flat plate the hysteresis effect disappears at a higher Mach Number. Furthermore, it was found that the reduction in heat transfer with increasing field strength is opposite in behavior from that for Couette flow.

THE FLOW ABOUT A CHARGED BODY MOVING IN THE LOWER IONOSPHERE. R. R. Hunziker. Convair Phys. Sect. Rep. ZPh-033, Apr. 1, 1959. 25 pp. 20 refs. Analysis using a simple gas model composed of electrons, ions, and neutral particles; a hydrodynamic description is given on the basis of Maxwell's transfer equations for a mixture. The conditions under which local statistical equilibrium can be assumed are discussed, and different approaches to determine the gas dynamic force in the subsonic, supersonic, and hypersonic cases are indicated. The reciprocal action of the flow electric field on the body is also analyzed, and a formula for the resultant electric force is given. Also includes calculation of the negative potential acquired by a plane body, and discussion of the solution of the external nonlinear problem which characterizes the electric potential and the electron distribution.

A MAGNETOHYDRODYNAMIC MODEL FOR A TWO-DIMENSIONAL MAGNETIC PISTON. R. X. Meyer. Space Tech. Lab. PRL TR 59-0000-00617, Mar. 4, 1959. 12 pp. USAF-supported calculation of the mass flow rate of gas leaking through the magnetic piston in the regime of continuum flow. The analysis is confined to a plane geometry rather than to a rotationally symmetric one. The principal assumption throughout the analysis consists in neglecting the kinetic energy of the gas (in a coordinate frame attached to the piston) compared with its internal energy and compared with the energy of the magnetic field. The gas therefore "percolates" through the field somewhat analogously to a liquid percolating through a porous medium. This assumption is verified numerically and a typical example is considered.

ON ONE-DIMENSIONAL CHANNEL FLOW IN THE PRESENCE OF A MAGNETIC FIELD. W. B. Bush. Space Tech. Lab. PRL TR 59-0000-00660, May 4, 1959. 17 pp. USAF-supported study covering the formulation of differential equations for the one-dimensional channel flow of a perfect gas. The simplifying assumptions introduced into the calculation are stated. The integration of the equations is performed for two cases, and the solutions are presented in analytical and graphical form. The results show that with increasing magnetic field the sonic point moves downstream from the channel's throat and that, in general, a larger exit area is needed to obtain a given supersonic flow Mach Number.

ELECTRICAL AND PRESSURE LOSSES IN A MAGNETOHYDRODYNAMIC CHANNEL DUE TO END CURRENT LOOPS. G. W. Sutton. G-E MSVD AL TIS R59SD431, July 22, 1959. USAF-supported investigation of the problem of end losses in a magnetohydrodynamic flow for incompressible inviscid flow in a rectangular channel. Termination of the magnetic field at the ends of the electrodes leads to electrical losses which increase with decreasing aspect ratio of the electrode section of the channel. The losses are also increased with increasing values of the generator coefficient. These electrical losses can be corrected by extensions of the magnetic field beyond the electrode region, but these corrections adversely affect the net pressure change through the device.

AXI-SYMMETRIC MAGNETO-GAS DYNAMIC CHANNEL FLOW. F. D. Hains and Y. A. Yoler. Boeing Sci. Res. Lab. FSL Rep. 12, D1-82-0008, Aug., 1959. 57 pp. 15 refs. Analysis of the channeling effect of the magnetic field produced by a circular loop of wire on the steady state flow at low magnetic Reynolds Numbers of an electrically conducting compressible gas in a circular channel of constant radius, coaxial with the magnetic field. Formal solutions are given for subsonic and supersonic flow, linearized for small values of the magnetic interaction parameter. Shock-tube investigations of wall pressures and wall temperatures are discussed.

DESIGN CONSIDERATIONS OF A STEADY DC MAGNETOHYDRODYNAMIC ELECTRICAL POWER GENERATOR. G. W. Sutton. G-E MSVD AL TIS R59SD432, Sept. 15, 1959. 47 pp. USAF-supported evaluation of the design requirements of a steady, d.c., magnetohydrodynamic electrical power generator. Expressions are derived for the generator power, size, efficiency, and magnet power. Losses due to heat transfer and electrical effects are calculated. Considerations of the Hall effect indicate that there is a relation between the pressure and magnetic field which yields the minimum length generator.

ON MAGNETOHYDRODYNAMIC PROPULSION. Arthur Kantrowitz and G. S. Janes. ARS 14th Annual Meeting, Wash., Nov. 16-20, 1959, Preprint 1009-59. 17 pp. USAF-supported study of the properties of plasma accelerators employing electrodes considered as circuit elements. It is shown that these devices have very low effective characteristic impedances, and that provision must always be made for recovery of the magnetic field energy before the plasma is expelled. These considerations, plus the assumption of electrode arc voltage drops, lead to a theorem relating the minimum instantaneous power, the efficiency, and the specific impulse.

PLASMA OSCILLATIONS. J. D. Jackson. Space Tech. Lab. PRL GM TR 0165-00535, Dec. 3, 1958. 55 pp. USAF-supported survey of the various aspects of plasma oscillations, including a discussion of dispersion equations, conditions necessary for the growth or decay of oscillations, the physical mechanism of growing or damping, and the possibility of arbitrary steady state solutions. The mathematical description is made in terms of solutions of an initial value problem in small amplitude (linearized) approximations. Some general results are derived for an arbitrary unperturbed velocity distribution of electrons and ions. From these expressions, the results for a stationary plasma in thermal equilibrium can be obtained. One-dimensional motion of a simple one-component plasma is assumed; collisions between particles and nonlinear effects are not considered; and appropriate generalizations for two-component plasmas (electrons and ions) are indicated.

ONE-DIMENSIONAL TREATMENT OF WEAK DISTURBANCES OF A SHOCKWAVE. Alan Powell. Gt. Brit., ARC CP 441, 1959. 12 pp. BIS, New York, $0.36. Study covering the case of a shock wave which enters a region of fluid initially at rest and whose motion is disturbed by interaction with sound waves or temperature fluctuations. The resultant sound waves and temperature changes behind the shock are discussed. Includes outline of a corrected version of an earlier treatment which considered an initially stationary shock wave. Numerical values of the interaction coefficients up to $M_1 = 5$ are given.

CONVERGING CYLINDRICAL DETONATION WAVE. Ya. B. Zel'dovich. (Zhurnal Teoret. i Exper. Fiz., Mar., 1959, pp. 782-792.) Sov. Phys. - JETP, Sept., 1959, pp. 550-557. 13 refs. Translation. Analysis considering the properties of detonation waves close to the normal wave. A theory is developed for the amplification of cylindrical converging detonation waves, which describes exactly the amplification in the initial stages of the process. By comparison with numerical calculations, it is shown that the theory remains satisfactory even for small radii and appreciable amplification of the wave.

A THEORETICAL INVESTIGATION OF SECOND-ORDER SUPERSONIC INTERFERENCE EFFECTS. B. J. Beane and M. T. Landahl. Sweden, Flygtekniska Försöksanstalten, FFA Rep. AU-II-93:1(TN1)(AFOSR TN 59-962), Apr., 1959. 17 pp. Presentation of an approximate solution, valid for high Mach Numbers, for the second-order supersonic flow problem of two interfering flow fields. The solution requires the spanwise curvature of the body flow field to be small. A further approximation leads to a very simple formula for the interference pressure, which is found to give relatively small errors in the case investigated. It is found that second-order interference effects may be large at Mach Numbers above 3. Thus, it is demonstrated that large gains in control surface efficiency may be obtained by placing the control surface in a region of high pressure from the body.

Internal Flow

APPROXIMATE METHOD FOR DETERMINING THE POTENTIAL FLOW ABOUT AN ARBITRARY AEROFOIL SECTION IN A TWO-DIMENSIONAL FINITE STREAM WITH PARTICULAR REFERENCE TO LARGE STREAM DEFLECTIONS. Appendix A - ANALYSIS USED TO DETERMINE THE SAMPLE AEROFOIL SECTIONS. Appendix B - NUMERICAL ANALYSIS TO DETERMINE THE REQUIRED STREAMLINE DISTORTION TO GIVE CONSTANT VELOCITY ALONG THE BOUNDING STREAMLINES. Appendix C - SAMPLE CALCULATION OF APPROXIMATE FLOW ABOUT AN ARBITRARY AEROFOIL IN A FINITE STREAM. D. G. Gould. Canada, NRC Aero. Rep. LR-260, Aug., 1959. 36 pp. Comparison of the flow about and on the surface of an airfoil section in a finite stream and that about and on the surface of the same airfoil section in an infinite symmetrical cascade. It is shown that, for most cases of practical interest, the differences are small for stream deflection angles up to 90°. The approximate flow about an arbitrary airfoil section in a two-dimensional finite stream may be obtained by using the methods existing for the determination of the flow about an arbitrary section in a cascade. The procedure, as applied to the finite stream approximation, is given using the interference method of cascade theory.

LOSSES IN A JET-FLAP COMPRESSOR CASCADE. E. F. Brocher. Cornell U. Grad. Sch. Aero. Eng. Rep., Sept., 1959. 63 pp. Study of jet-flap compressor blades to obtain more accurate data and to evaluate the method as to its efficiency in preventing stall. The method used by Scholz for measurements on two-dimensional cascades has been extended to include mass and energy input into the main flow by trailing-edge jets. Pressure recovery and mixing losses downstream of the cascade are theoretically investigated, and the need for low jet velocities has been emphasized. Improvements which can be expected by increasing the jet width but keeping the jet coefficient constant are demonstrated. Results are given in the form of wake profiles, pressure rise, axial and tangential force coefficients, turning angle, and cascade polars.

AN EXPERIMENTAL INVESTIGATION OF A SUPERSONIC TWO-DIMENSIONAL PERFORATED INLET AT A NOMINAL FREE STREAM MACH NUMBER OF 2.5. J. P. C. Clark. UTIA TN 24, Nov., 1958. 48 pp. Discussion of tests conducted on a two-dimensional supersonic diffuser in the form of a reversed Laval nozzle at a nominal free-stream Mach Number of 2.5 and a design isentropic contraction ratio of 2.637. The resulting bow shock is induced to move into the intake and eventually past the throat by perforating the diffuser walls. A series of 19 static pressure taps in the diffuser walls provided pressure distributions as a function of perforation and exit areas. Stable operation of the diffuser is demonstrated with the shock in any position from detached to downstream of the throat, and a maximum pressure recovery of 87.5% is obtained at the throat with an associated mass flow loss of 21%.

DESIGN AND DEVELOPMENT OF PRECOMPRESSION BUMP SURFACES FOR USE WITH SUPERSONIC INLETS. I - THEORETICAL ANALYSIS. Appendix A - NUMERICAL APPLICATIONS. Appendix B - DETERMINATION OF VELOCITY COMPONENTS BEHIND A NON-CIRCULAR CONICAL SHOCK BY THE USE OF THE HODOGRAPH DIAGRAM. Appendix C - IBM 650 PROGRAM FOR THE SOLUTION OF AN ELLIPTICAL CONE FLOW FIELD AND FOR THE STREAM SURFACE DEVELOPMENT. Appendix D - ERROR ANALYSIS OF HORD-KAHANE STREAMLINE APPROXIMATION. R. E. Bower, R. S. Davies, and R. E. Dowd. Grumman Aircraft Eng. Corp. Res. Dept. Rep. RE-122, Aug., 1959. 77 pp. Presentation of a new approach to the design of high-speed inlets. The concept of a contoured or "bump" surface ahead of an inlet is to simultaneously precompress the entering main stream and wash the low energy boundary layer accumulation ahead and to either side of the inlet by the action of a local transverse pressure gradient set up on the bump surface. Three theories are presented; they involve the superposition of known linearized triangular wing and known nonlinear conical flow solutions. Advantages of accuracy and ease of application are pointed out, and numerical examples are given for possible designs at Mach Numbers of 1.60 and 3.0. A typical IBM 650 program is also presented.

NON-EQUILIBRIUM THEORY OF AN IDEAL-DISSOCIATING GAS THROUGH A CONICAL NOZZLE. N. C. Freeman. Gt. Brit., ARC CP 438, 1959. 10 pp. BIS, New York, $0.54. Investigation of the one-dimensional flow of ideal dissociating gas through a conical nozzle using the simple rate equation of Freeman. The effect of the rate parameter λ (the ratio of the time scale of the motion to that of dissociation) on the flow is investigated for one set of initial conditions. It is shown that thermodynamic equilibrium cannot be achieved in the conical section if λ is finite. The composition of the gas becomes frozen at some point in the nozzle and further expansion causes no further recombination.

STATIC FORCE TESTS OF SEVERAL ANNULAR JET CONFIGURATIONS IN PROXIMITY TO SMOOTH AND IRREGULAR GROUND. E. E. Davenport, R. E. Kuhn, and I. R. Sherman. US, NASA TN D-168, Nov., 1959. 13 pp. Investigation made to determine the effectiveness of a discontinuous annulus, the effects of changing from circular to elliptical plan forms, and the effect of irregularities in the ground at zero forward speed. The results indicate that appreciable thrust augmentation can be obtained with a discontinuous annular jet, but the augmentation decreases with increasing percentage of open area in the jet curtain. Thrust augmentation is obtained with elliptical plan forms, but it is less than that of a circular plan form with the same circumference. Surface irregularities decrease the augmentation with the jet very close to the ground.

LAMINAR MIXING OF STREAMS OF DIFFERENT GASES. L. G. Napolitano and A. Pozzi. U. Naples Inst. Aero. TN 1 (I.A. Rep. 10) (AFOSR TN 59-977), Apr., 1959. 61 pp. 14 refs. Presentation of solutions for plane, isobaric, laminar mixing of two streams. For the case of constant velocity ($u = u_1 = u_2$) mixing an exact, closed-form solution is derived for the general case of the Lewis Number (Le) other than one. With the help of this exact solution, it is shown that the assumption $Le = 1$ may lead to substantial errors in the temperature profiles. An approximate solution, based on the integral method, is presented for the general case without the limitations of constant Schmidt Number and constant density-viscosity product. The solution by this method proves to be simple, and accuracy is determined by comparison with the previously mentioned closed-form solution and with numerical solutions obtained by means of a computer for a number of indicative cases. The comparison shows that velocity profiles and concentration profiles are accurate to the order of 3% to 4% and 8% to 10% for velocity and concentration profiles, respectively.

Stability & Control

ANALYSIS OF THE DYNAMIC LATERAL STABILITY OF A DELTA-WING AIRPLANE WITH FREQUENCY-DEPENDENT STABILITY DERIVATIVES. Appendix A - FREQUENCY-RESPONSE FUNCTIONS. Appendix B - ILLUSTRATIVE EXAMPLE OF THE USE OF UNEQUAL FREQUENCY INTERVALS FOR DETERMINING THE TIME RESPONSE TO A UNIT IMPULSE FROM FREQUENCY-RESPONSE DATA. A. E. Brown and A. A. Schy. US, NASA TN D-113, Nov., 1959. 44 pp. Investigation to determine the effect of frequency-dependent stability derivatives on the lateral stability of a delta wing aircraft for a flight condition where test results had shown large variations of the stability derivatives with frequency over a range of frequencies. Time histories of rolling velocity and angle of sideslip are obtained by using the Fourier transform to solve the lateral equations of motion. The results show that the frequency effects of the stability derivatives can cause considerable changes in predicted aircraft motions, and that amplitude effects of these derivatives can also be important in calculating aircraft responses.

THE CONTROL AND STABILITY OF HYPERSONIC AIRCRAFT. Appendix I - A MECHANICAL ANALOGUE-SIMULATOR OF THE LONGITUDINAL CONTROL PROBLEM. Appendix II - A SIMULATOR OF LATERAL CONTROL. T. R. F. Nonweiler. Aircraft Eng., Nov., 1959, pp. 322-329. Analysis of the criteria associated with hypersonic flow above the stratosphere. The equations of motion are derived and solved, indicating the possible sources of error. Also covered are the stability of the longitudinal motion, longitudinal response, stability of the lateral motion, lateral response, and stick-free stability. It is concluded that the motions in certain degrees of freedom -- the speed and direction of the c.g. path and the rate of roll -- are virtually in neutral equilibrium (for durations of a few cycles of the oscillations); because of the high speed of flight and the nature of the response, gusts will have little effect in provoking accelerations or oscillations; movements of the controls will cause oscillations of the aircraft, and tables are presented for deducing the response to elevator, rudder, and aileron; the stick movements necessary to damp the oscillations will not affect the phugoid stability with the result that altitude will tend to "drift"; a free aileron will oscillate harmonically, unless given precise aerodynamic balance; and a free-elevator will oscillate in a combined two-phase motion with aircraft incidence and the other aircraft degrees of freedom.

Wings & Airfoils

A METHOD FOR CALCULATING AERODYNAMIC LOADINGS ON THIN WINGS AT A MACH NUMBER OF 1. J. L. Crigler. US, NASA TN D-96, Nov., 1959. 30 pp. 10 refs. Presentation of a method which differs from previously developed lifting-surface procedures in that the chordwise integrations are performed analytically. The spanwise integrations are then performed by numerical procedures. Calculated results are compared with experimental data for a swept wing-body configuration. The magnitude and the distribution of the spanwise loading of the calculated data at a free-stream Mach Number M_o of 1.0 are in good agreement with experimental data obtained at M_o = 0.98 and 1.03.

THE DEVELOPMENT OF FLOW SEPARATIONS ON THE AVRO 707A AIRCRAFT; A COMPARISON OF WIND TUNNEL AND FLIGHT BASED ON THE MEASUREMENT OF SURFACE PRESSURES. D. G. Hurley, A. A. Keeler, and T. H. Trimble. Australia, ARL AN 173, May, 1959. 41 pp. Comparison showing that both the model and the aircraft flow separations occur first near the tips and spread inboard with increasing C_L. The flow separates from the leading edge as a laminar layer in both cases. For lift coefficients of about 0.65, the flow separation spreads inboard much more rapidly on the wind tunnel model than on the aircraft. This is due to the fact that, as the separation spreads inboard on the model it remains laminar, whereas when the separation on the aircraft has spread inboard of about 70% span it changes to the turbulent type, after which its rate of inboard spread is greatly reduced. This difference arises because the flight Reynolds Number is much greater than the model Reynolds Number.

A SYSTEMATIC KERNEL FUNCTION PROCEDURE FOR DETERMINING AERODYNAMIC FORCES ON OSCILLATING OR STEADY FINITE WINGS AT SUBSONIC SPEEDS. Ch. E. Watkins, D. S. Woolston, and H. J. Cunningham. US, NASA TR R-48, 1959. 48 pp. 32 refs. Derivation of a numerical solution of the integral equation which relates oscillatory or steady lift and downwash distributions in subsonic flow. The procedure has been programed for the IBM 704 electronic data processing machine and yields the pressure distribution and some of its integrated properties for a given Mach Number and frequency and for several modes of oscillation in 3 to 4 min. Results of several applications are presented.

CALCULATION OF THE THICKNESS AND RADIAL FORCE DISTRIBUTION FOR A RING WING HAVING ZERO DRAG AT SUPERSONIC SPEEDS. R. M. Licher. Douglas Rep. SM-23579, May 27, 1959. 22 pp. Application of the linearized theory to determine a set of thickness distributions for ring wings with zero wave drag over a certain range of ring radius to wing chord values. Both the thickness and the radial force distributions are computed. The flow field within the ring is calculated by taking a pair of parallel Mach planes of infinitesimal strengths and opposite signs and rotating them about an axis parallel to the free stream. Between such a pair of planes the flow is disturbed and the pressure changed, but, behind them, a uniform flow field has only been displaced from its initial position but not otherwise disturbed. Two examples illustrating the application of the method are also discussed.

METHOD FOR CALCULATING THE DOWNWASH BEHIND SWEPTBACK WINGS IN SUPERSONIC FLOWS. S. N. Chaudhuri and V. D. S. Prasad. Aero. Soc. India J., Aug., 1959, pp. 68-73. Development of a simplified method for the calculation of supersonic downwash behind wings of any plan form. This is done by replacing the spanwise circulation distribution of the wing by means of Multhopp's interpolation functions. The downwash integrals behind the wing due to these interpolation functions are reduced to elliptic functions for convenience of tabulation. The downwash behind the wing is obtained by multiplying the tabulated values of downwash by the appropriate spanwise circulations. The downwash calculations made for a sweptback wing show good agreement with those using Mirel's method and check very well with experimental values available up to Mach 1.15.

WINGS WITH MINIMUM DRAG DUE TO LIFT IN SUPERSONIC FLOW. Ingeborg Ginzel and Hans Multhopp. J. Aero/Space Sci., Jan., 1960, pp. 13-20, 36. Application of the criteria of Jones, stating that the downwash in the combined flow field must be constant over the plan form, to determine both the lift distribution for minimum drag and the actual shape of the lifting surface. The method derives the pressure distribution and the distribution of angle of attack for a tapered sweptback wing. Both of these distributions are given at 31 stations over the span in the form of a three-term Legendre series over the chord. A considerable reduction in drag due to lift seems possible when compared with an untwisted, uncambered wing of the same plan form. The greatest reduction in drag occurs for wings with both edges swept back and with a subsonic leading edge.

THE USE OF ARTIFICIAL SINGULARITY DISTRIBUTIONS TO FIND MINIMUM DRAG FOR FIXED BASE AREA IN SUPERSONIC FLOW. E. W. Graham and B. J. Beane. Douglas Rep. SM-23698, Sept. 30, 1959. 15 pp. Application of the method of artificial singularities to the problem of finding minimum thickness drag in supersonic flow, subject to the constraint of fixed base area. A suitable artificial singularity distribution employing sources as well as lift and side-force elements is described. The method is illustrated for the special example of a Mach envelope rim which lies entirely in one plane, the plane being swept with respect to a normal to the free stream direction. For wings or wing-body systems corresponding to the prescribed Mach envelope rim, the minimum value of supersonic wave drag under the restriction of fixed base area is found. Extension of the method to more general cases where the Mach envelope rim does not lie in a single plane is also indicated.

THE SHAPES AND LIFT-DEPENDENT DRAGS OF SOME SWEPTBACK WINGS DESIGNED FOR $M_0 = 1.2$. Appendix I - THE SHAPE OF A SWEPTBACK WING WHICH PRODUCES A CONSTANT SPANWISE LOAD DISTRIBUTION WHEN COMBINED WITH A CYLINDRICAL FUSELAGE. Appendix II - THE SHAPE OF THE CENTRE-SECTION OF A SWEPTBACK WING DESIGNED TO HAVE VARIOUS CHORDWISE LOAD DISTRIBUTIONS. Appendix III - CALCULATION OF CENTRE OF PRESSURE AND LIFT-DEPENDENT WAVE DRAG FROM CROSS-LOAD DISTRIBUTIONS. J. A. Bagley and J. A. Beasley. Gt. Brit., RAE Rep. Aero.2620, June, 1959. 87 pp. 15 refs. Calculation of camber and twist distributions needed to produce a constant spanwise C_L-distribution and certain linear chordwise load distributions for a set of 34 thin sweptback wings. The wing plan forms cover a range of aspect ratios from 2.0 to 3.5 and leading-edge sweep angles from 55° to 70°. The lift-dependent vortex and wave drags associated with these loadings have also been calculated, and appear not to be excessive in almost all the cases considered.

PRESSURE MEASUREMENTS AT THE CENTRE OF A 40° SWEPTBACK WING WITH R.A.E. 101-10 SECTIONS AT ZERO INCIDENCE AND TRANSONIC SPEEDS. Appendix - TUNNEL WALL INTERFERENCE EFFECTS. J. E. Rossiter. Gt. Brit., RAE TN Aero.2630, June, 1959. 30 pp. Investigation over a range of Mach Numbers from 0.5 to 1.22 at zero wing incidence for a Reynolds Number of 1.3 million based on the wing chord. Between Mach Numbers of 0.88 and 0.94 the pressure distribution in the wing-body junction changed from subsonic to one having the shape associated with the flow at a supersonic free-stream Mach Number. At subsonic speeds, agreement between the measured pressure distribution in the wing-body junctions and an estimate made by the method given by Küchemann and Weber was only fair, mainly because the body side does not act as a true reflection plane. At supersonic speeds, the method given by Bagley for estimating the pressure distribution at the center section gives the correct shape for the distribution at Mach Numbers as low as 1.02 but the magnitude is in error, particularly over the rear of the section.

FORCES ON WING-FUSELAGE COMBINATIONS IN SUPERSONIC FLOW. J. H. Clarke. Boeing Sci. Res. Lab. FSL Rep. 11, D1-82-0018, Aug., 1959. 37 pp. 17 refs. Derivation of expressions for the aerodynamic forces acting on a general wing-fuselage combination in supersonic flow, using reverse flow relations. The drag, lift, spanwise and chordwise lift distributions, and wing moments are treated. It is shown that the aerodynamic forces can be determined from a solution for the pressure on the fuselage surface within the domain of dependence of the wing, this region being selected on the basis of relative ease of computation. The reverse-flow theorem is re-examined, and the method is shown to be applicable to other linear, hyperbolic problems in mathematical physics.

EFFETS D'INTERACTION DUS AUX NAPPES TOURBILLONNAIRES D'APRES LA THEORIE DES CORPS ELANCES. A. von Baranoff. La Recherche Aéronautique, Sept.-Oct., 1959, pp. 3-11. 10 refs. In French. Application of the slender body theory to derive the general formulas describing the forces and moments induced over the rear part of a missile by vortex sheets generated at the wing. Numerical examples are presented to illustrate the applicability of the derived formulas. Covered are: (a) the lift induced in symmetrical flow over a system composed of a fuselage and two plane successive wings; and (b) the lift, the lateral force, and the rolling moment induced by the effect of slip over a system comprising a fuselage, a plane front wing, and a cruciform rear wing. A comparison with experimental results shows that the theory is satisfactory in predicting the type of influence due to the geometric parameters. The application of a semiempirical correction method allows the Mach Number effect to be taken into account.

AEROELASTICITY

VIBRATION AND FLUTTER OF CYLINDRICAL AND CONICAL SHELLS. Yechiel Shulman. MIT ASRL TR 74-2 (AFOSR TR 59-776), June, 1959. 174 pp. 55 refs. Analysis of the theory of thin shells and presentation of some simplified general expressions which reduce to Donnell's expressions in the case of circular cylindrical shells. An appropriate variational principle is formulated and the similarity to shallow-shell theory is shown. The investigation of the free vibration problem of conical shells indicates the existence of an optimum method which satisfactorily accounts for the opposing effects of taper on membrane and bending frequencies. It is shown that the method may be used to obtain better approximations to the frequencies by the process of including more expansion modes in the analysis. The study of the general shell and panel flutter problem indicates the general characteristics of the phenomenon, which are common to a wide variety of structural components of different geometry and stiffness characteristics. Results of the flutter problem of cylindrical shells show that the flutter speed and frequency of the shell reach a minimum for a particular mode number n which is different from the one associated with the minimum frequency of the shell. In the conical-shell flutter problem, the effect of taper is to increase the flutter speed of the shell.

FLUTTER OF CURVED PANELS. J. E. Yates and E. F. E. Zeijdel. MRI Rep. (AFOSR TN 59-1031), Sept., 1959. 38 pp. Analysis of flutter of curved panels considering the general equations of motion of shallow cylindrical shells. The initial curvature is taken as circular in the chordwise direction. The special case of infinite aspect ratio is considered, and appropriate equations are developed for finite aspect ratio panels. Linearized three-dimensional aerodynamic forces are incorporated in the flutter equations of motion. Results are obtained for unit and infinite aspect ratio curved panels with simply supported edges for two Mach Numbers ($M = 1.5$ and 2). The flutter boundaries clearly indicate the strong dependence of panel flutter on curvature. Increasing curvature has a destabilizing effect on the panel up to a critical value of curvature. At the critical value, the frequencies of the first and second chordwise modes coalesce and a very large thickness is required for stability. Beyond this critical value, increasing curvature has a stabilizing effect, but it is proved that two mode results are unconservative in this region due to a frequency coalescence between the first and third chordwise modes.

AIRPLANES

Cockpits, Canopies, Windshields

DESIGN OF TRANSPARENCIES. J. S. Przemieniecki. RAeS J., Nov., 1959, pp. 620-636. 26 refs. Analysis of the methods of calculating temperature distribution in transparent panels subjected to kinetic heating (or cooling), considering the effects of the nonuniform temperature distribution, differential expansion, and the edge restraints preventing thermal deformations. The choice of design cases for combined pressure and thermal loading is considered and it is shown that, in general, deceleration maneuvers combined with outward pressure constitute the design criteria for transparencies. The effects of various parameters on the magnitude of thermal stresses are analyzed; these include the effects of altitude, temperature, deceleration, and material properties. It is shown that, for given material and panel geometry, the thermal stresses depend mainly on the following parameters: total temperature change, acceleration (or deceleration), and the Biot Number based on the panel thickness. Practical design aspects are also considered, such as choice of materials, strength, panel geometry, mounting of panels, and fail-safe design.

CHEMISTRY

A STUDY OF THE INTERACTION BETWEEN CARBON AND DISSOCIATED GASES. W. G. Zinman. G-E MSVD AL TIS R59SD457, Nov. 5, 1959. 13 pp. 23 refs. Study of the reaction of active nitrogen (atomic nitrogen) with carbon at 800°C. The consistent failure to obtain measurable amounts of cyanogen as a reaction product showed that collision efficiency of cyanogen formation was less than 10^{-4}. On the other hand, when nitrogen containing 30 ppm of hydrogen was activated, significant amounts of HCN were obtained. These results indicate that atomic hydrogen promotes a reaction between atomic nitrogen and carbon on at least one out of every thousand collisions. A mechanism accounting for these results is postulated.

MATERIALS

Metals & Alloys

QUALITATIVE ASPECTS OF FATIGUE OF MATERIALS. H. N. Cummings. USAF WADC TR 59-230, Sept., 1959. 250 pp. 323 refs. Qualitative discussion of the variables affecting the fatigue life and strength of structural metals. Included are such aspects as: the relation of fatigue properties to other physical properties; the statistical nature of fatigue strength and life; variability in fatigue strength and life; factors affecting fatigue test results; effect of stress raisers; notch strength reduction factors and sensitivity; effect of metallurgical treatment; effect of mechanical treatment; effect of environmental conditions; effect of damping on fatigue; and acoustic fatigue. Some theories on the mechanism of fatigue are also briefly discussed.

FATIGUE DAMAGE DURING COMPLEX STRESS HISTORIES. Appendix A - ANALYSIS OF STRAIN-AGING IN COLD-DRAWN-STEEL WIRE. Appendix B - COMPARISON OF DATA WITH OTHER THEORIES OF CUMULATIVE FATIGUE DAMAGE. H. W. Liu and H. T. Corten. US, NASA TN D-256, Nov., 1959. 56 pp. 11 refs. Investigation of the influence of complex stress histories on the fatigue life of members in order to determine the relation between the fatigue life and the relative number and amplitude of imposed cycles of stress. Stress history is taken into account in terms of the number of damage nuclei initiated by the highest applied stress and the propagation of damage by all subsequent cycles of stress. Data obtained on wire specimens of 2024-T4 and 7075-T6 aluminum alloy and hard-drawn steel are analyzed statistically, and completely reversed two-stress repeated block experiments are performed and analyzed to verify the hypothesis that the fatigue life is adequately described by a simple two-parameter expression involving (a) the per cent of cycles at the high stress and (b) a stress interaction factor. The experimentally determined values of this stress interaction factor are correlated with the values of the high and low stress by a simple power relation.

MATHEMATICS

Physical Applications

DYNAMICS OF STRUCTURES BY TRANSFER MATRICES. E. Pestel. Hannover Tech. Hochsch.

Inst. Mech. TR 1 (AFOSR TR 59-95), June, 1959. 182 pp. 36 refs. Applications of transfer-matrices for the solution of complex elastic vibration and stability problems. Discussion includes the following subjects: calculations for stress and strain, free bending vibrations, and forced vibration of rotating discs; a catalog of transfer matrices for straight beams, curved and twisted beams, and beams with special conditions; spring coupling of beams; delta matrices and other modifications of transfer matrices; application to structural analysis of single- and multicell box beams; and applications to plate vibrations.

MISSILE, ROCKET, & SPACE TECHNOLOGY

RANGE AND ACCURACY OF LONG-RANGE BALLISTIC MISSILES. I. G. Henry. Brit. Interpl. Soc. J., Aug., 1959, pp. 88-92. Calculation of the surface-to-surface range of a ballistic missile by a simple geometrical method. The errors in range resulting from errors in speed and departure angle are computed by a Taylor series expansion of the range function. Some practical considerations which influence the choice of trajectory are cited. Factors such as oblateness of the earth, local irregularities of gravity near the launch site, and precise shape of the powered trajectory and re-entry path were not included in the consideration.

POWER SERIES SOLUTION OF ROCKET EQUATIONS OF MOTION. R. C. Meacham. RCA Data Proc. TR 45 (AFMTC TR 59-18), Sept. 18, 1959. 117 pp. Presentation of truncated Taylor's series solutions of the equations of motion for rocket flight under a variety of conditions. The position coordinates of the rocket are presented as polynomial functions of time; various terms and parameters appearing in the equations of motion are introduced along with some of the terminology and symbols; and a method of solution is indicated for the case of free flight in a vacuum, assuming a spherical earth gravitational field. Truncation error in the vicinity of apogee or perigee is investigated under several combinations of different altitudes, speeds, and time intervals. The solution for the re-entry drag problem under certain simplifying assumptions is also indicated, and the method of solution is extended to the case in which nonlinear variations of mass, air pressure and density, thrust force magnitude, drag coefficient, Mach Number, and velocity of sound are all taken into account in a "gravity-turn" flight.

DESIGN PARAMETERS AND OPTIMIZATION OF MISSILE TRAJECTORIES. C. A. Traenkle. ZFW, Oct., 1959, pp. 287-293. Analysis of the design parameters of missiles and their influence on the overall missile performance. The interrelation between the characteristic parameters of the propulsion system, of the program of the power phase, and of the trajectory elements is established, and it is found that there exists a critical geocentric angle below which ballistic-type trajectories are optimal, and beyond which the optimal solution is provided by a special satellite orbit. Results for the example of conventional chemical propellants are presented, and the applicability of the method to other propulsion systems is outlined.

OPTIMUM EXHAUST VELOCITY FOR LOW-THRUST ESCAPE. L. J. Berman. MIT Dept. Aeron. & Astron. Rep. (AFOSR TN 59-929), Sept. 1, 1959. 13 pp. Study covering the determination of the optimum value of exhaust velocity for escape orbits of vehicles with power-scaled propulsion systems. The effect of low accelerations on the optimum choice of exhaust velocity is shown along with the effect on the actual performance of the vehicle. The existence of a maximum for this choice, independent of the conditions of flight, is shown.

OPTIMUM ROCKET TRAJECTORIES. I - INITIAL VALUE VARIATIONAL SOLUTIONS. D. O. Dommasch and R. L. Barron. Aero/Space Engrg., Jan., 1960, pp. 46-50, 60. 26 refs. Presentation of the physical and mathematical requirements for the solution of optimum trajectory problems on an initial value basis. It is shown that the use of the equations of motion to restrain an optimum problem does not provide more than a valid path function equation, which still must be integrated along with the equations of motion and kinematic relations to provide a specific trajectory. This is done by use of either iterative techniques, relaxation procedures, or mapping techniques which serve to define envelope performance by systematically varying parameters to provide a complete coverage of obtainable performance. In the case of one or more Lagrange multipliers introduced due to the existence of anholonomic or pseudoholonomic restraints, the value of the multiplier chosen at the outset is a required initial condition which must be varied to shift the path termination conditions. A simplified optimum boost problem is formulated in outline form to demonstrate the overall procedures to be followed.

AN APPLICATION OF DYNAMIC PROGRAMMING TO THE DETERMINATION OF OPTIMAL SATELLITE TRAJECTORIES. Richard Bellman and Stuart Dreyfus. Brit. Interpl. Soc. J., Aug., 1959, pp. 78-83. Discussion of a simplified satellite trajectory problem corresponding to a flat earth assumption, as posed and treated by Okhotsimskii and Eneev. One of the principal results is deduced using standard variational arguments. A numerical solution is presented, based upon the functional equation technique of dynamic programming, as well as a proof of the fundamental result in the analytical solution. The same computational approach may also be applied to more realistic trajectory problems.

COMPOSITE TRAJECTORIES YIELDING MAXIMUM COASTING APOGEE VELOCITY. Stanley Ross. (ARS 13th Annual Meeting, New York, Nov. 17-21, 1958.) ARS J., Nov., 1959, pp. 843-848. Analysis considering the optimization of thrust direction (angle of attack) during the second of two adjacent satellite ascent stages. At second stage burnout, a coasting ellipse is to carry a third and final stage to some prescribed orbit height. An expression for a thrust direction program to maximize velocity at the apogee of this coasting arc is obtained. Assuming second stage thrust to be of constant magnitude, the equations of motion can be integrated in closed form. During this phase only, the earth is assumed flat; aerodynamic effects are neglected beyond first stage burnout. Under these assumptions, determination of the optimum trajectory is reduced to a one-parameter iteration, readily effected by machine or hand calculation. Forms are derived for the second variation, as well as for the total variation. These expressions permit the investigation of conditions which insure mathematically optimum paths. Finally, a sample calculation is presented, using announced Vanguard data as parameters.

SOME THRUST AND TRAJECTORY CONSIDERATIONS FOR LUNAR LANDINGS. R. J. Weber and W. M. Pauson. US, NASA TN D-134, Nov., 1959. 37 pp. 11 refs. Discussion of a method for accomplishing soft landings on the moon, which is first to establish a circumlunar orbit and then to transfer to the lowest acceptable altitude by a minimum-energy elliptical path. After braking to a halt, a vertical descent is made consisting of free fall and a final upward thrust application to decelerate the vehicle. The characteristic velocity increment ΔV for a typical landing (starting from orbit) is 6,880 ft. per sec. The effects of trajectory errors and thrust level are discussed.

ACCURACY REQUIRED FOR A RETURN FROM INTERPLANETARY VOYAGES. R. M. L. Baker, Jr. Brit. Interpl. Soc. J., Aug., 1959, pp. 93-98. 15 refs. Discussion of the navigational accuracy required for the application of braking-ellipse techniques to a return from the Moon or planets, in which it is shown that a large portion of the total aerodynamic heating and drag during the braking-ellipse maneuver is encountered in the transitional aerodynamic regime between free-molecule flow and continuum flow. In the case of re-entry from a ballistic orbit, on a return leg of a round trip to Venus, the target at the Earth is found to be a thin circular annulus. Stringent accuracy requirements suggest the use of small auxiliary retro-rockets to "steer" the vehicle into the correct atmospheric level after circling the Earth once. The cases of landings on Mars and Venus are also covered.

THE RE-ENTRY OF MANNED EARTH SATELLITES. R. H. Plascott. Gt. Brit., RAE TN Aero. 2640, Aug., 1959. 37 pp. 11 refs. Discussion of the use of aerodynamic forces in re-entry and comparison between the relative merits of lifting and nonlifting vehicles. Two possibilities are studied: (a) a nonlifting vehicle of high drag/mass ratio (C_DS/m), whose performance could be enhanced by the use of a parachute or similar device; (b) a lifting vehicle, whose configuration should be designed to give as high lift/mass (C_LS/m) and drag/mass parameters as possible. Techniques are suggested for the initial maneuver out of orbit and for lifting re-entries.

Spacecraft

SOME GENERAL CONSIDERATIONS OF THE HEATING OF SATELLITES. A. J. Eggers, Jr., T. J. Wong, and R. E. Slye. (ASME Av. Conf., Los Angeles, Mar. 8-12, 1959.) ASME Trans., Ser. C - HT, Nov., 1959, pp. 308-314. 12 refs. Study of heating problems in planetary atmospheres and in interplanetary space. The use of blunt shapes and small entry angles in combination with known radiation, heat sink, and ablation cooling techniques appears adequate to handle the entry problem at speeds up to escape speed. Return flights from distant planets may be characterized by much higher entry speeds, and more advanced techniques for coping with the heating problem may be required. Heating during entry into the atmospheres of planets neighboring earth tends to be more or less severe than that in the earth's atmosphere, depending on whether the planets are larger or smaller than earth. Heating in interplanetary space due to solar radiation becomes severe only if a satellite approaches to within a small fraction of an astronomical unit of the sun, or if the vehicle has an insufficient radiation shield. A cooling problem is encountered in the outer portion of our solar system, and an auxiliary power source may be required to supplement the reduced amount of heat from the sun.

EARTH-PERIOD (24-Hr) SATELLITES. J. H. Hutcheson. ARS J., Nov., 1959, pp. 849-853. Study of an earth-period satellite which has an orbital period of revolution exactly equal to the earth's period of rotation on its axis (one sidereal day). The discussion considers the type of relative motion which will exist in a practical case where the orbital plane is inclined, the motion is elliptical, and the perturbations due to the moon, sun, and the earth's oblateness are taken into account. Several illustrations are given showing the effect of various different orbital values on the satellite ground track. Practical applications are discussed including the use of an inclined orbit for observation purposes.

ORBITS OF ARTIFICIAL SATELLITES. W. T. Thomson. Brit. Interpl. Soc. J., Aug., 1959, pp. 83-87. Study of the general motion of artificial satellites under an inverse square central force, showing that the orbits can be specified by three nondimensional parameters at rocket burnout. The conditions for circular, elliptical, parabolic, and hyperbolic orbits are discussed. Expressions giving the periods of closed orbits in terms of the parameters are derived.

THE GEODETIC USE OF ARTIFICIAL EARTH SATELLITES. I, II. Systems Lab. Final Rep. (AFCRC TR 59-276, Pts. I, II), Aug. 15, 1959. 119; 87 pp. 53 refs. Discussion of various ways in which artificial earth satellites may be used to provide the geodesist with more accurate information about the relation between different geodetic data. These include both optical and electronic techniques and, in each case, the predicted accuracy of the principal datum ties is discussed. Connection methods based both on orbit prediction and on simultaneous visibility of the satellite from the data are investigated. Detailed analyses are given of the accuracy of various methods, the equipment design and performance, and the effects of physical phenomena, such as ionospheric and atmospheric fluctuation, on the measurements.

NUCLEAR ENERGY

DYNAMIC ANALYSIS OF A NUCLEAR ROCKET ENGINE SYSTEM. B. R. Felix and R. J. Bohl. (ARS 13th Annual Meeting, New York, Nov. 17-21, 1958.) ARS J., Nov., 1959, pp. 853-862. 17 refs. Analysis presenting a mathematical model which is used to study system dynamic and control characteristics with an analog computer. A typical solid structured heat exchanger-type nuclear engine is described together with nonlinear dynamic equations describing its characteristics. Distributed parameter effects in the heat transfer processes are presented, and methods of simulation are discussed. The analysis, together with considerations of nuclear vehicle applications, is used to develop system dynamic performance criteria.

POWER PLANTS

Jet & Turbine

AN EXPERIMENTAL STUDY OF ROTATING STALL IN A TWO-STAGE AXIAL COMPRESSOR. R. F. Meyer. Canada, NRC Aero. Rep. LR-259, Aug., 1959. 53 pp. 15 refs. Study of the stalling behavior of an Orenda CT-100 compressor at the constant operating speed of 3,000 r.p.m. Rotating stall was observed to commence at a mass flow coefficient of 0.435 and, as the mass flow was reduced, several different patterns of rotating stall were observed. In two ranges of operation steady patterns consisting of three rotating stalls were observed, in two other ranges of operation rotating stall was observed but the stall patterns were continually changing, while for very low mass flow operation the flow over the whole of the annulus appeared to be stalled. Reversed flow within the stalls was found to be an important feature of rotating stall.

Ram-Jet & Pulse-Jet

RECENT ADVANCES IN RAMJET COMBUSTION. G. L. Dugger. ARS J., Nov., 1959, pp. 819-827. 81 refs. Review and discussion of theoretical and experimental data on ram-jet engine development, including unconventional systems for future applications. Covered are: basic information on, and interpretation of, combustion processes; the advantages and disadvantages of higher temperatures; ways to circumvent the effect of the total (stagnation) temperature of free stream on the total temperature rise in the combustor; and results of external burning experiments for speeds above Mach 6.

Rocket

VAPORIZATION OF PROPELLANTS IN ROCKET ENGINES. R. J. Priem and M. F. Heidmann. (ARS 13th Annual Meeting, New York, Nov. 17-21, 1958.) ARS J., Nov., 1959, pp. 836-842. 26 refs. Analysis presenting the theory required to calculate the vaporization rates in a rocket engine, based on a model considering propellant vaporization as the rate controlling combustion process. Included in the model are changes in combustion gas velocity, droplet velocity, temperature, and mass. The vaporization rates of heptane, ammonia, hydrazine, liquid fluorine, and liquid oxygen sprays are computed for various log probability distributions and mass median drop sizes of the spray. The rates are also calculated for an engine operating with various injection velocities, final gas velocities, initial propellant temperatures, and chamber pressures. The calculations of the per cent of propellant vaporized are correlated with an effective chamber length, chamber pressure, final gas velocity, and initial fuel temperature. A method of analysis that relates experimental rocket engine performance to the quantity of liquid propellant vaporized suggests that incomplete vaporization is responsible for combustor inefficiency.

SCALING PROCEDURES FOR ROCKETS UTILIZING LIQUID PROPELLANTS OF VARIABLE COMPOSITION AND MIXTURE RATIO. S. S. Penner. Sundstrand Turbo S/TD 1733 TN 7 (AFOSR TN 59-908), Aug. 31, 1959. 18 pp. 13 refs. Derivation of generalized scaling rules for liquid-fuel rocket engines on the assumption that the dependence of the overall effective conversion time is a known function of propellant mixture ratio and propellant type. It appears that the completed test development of any particular propellant combination, together with fundamental studies of the overall dependence of conversion time on mixture ratio and propellant type, is sufficient to permit rational scaling for all propellant combinations through the use of similarity principles. The analysis emphasizes the importance of continued basic research on the mechanism and rates of combustion reactions in engines.

CONTROL OF COMBUSTION-CHAMBER PRESSURE AND OXIDANT-FUEL RATIO FOR A REGENERATIVELY COOLED HYDROGEN-FLUORINE ROCKET ENGINE. E. W. Otto and R. A. Flage. US, NASA TN D-82, Nov., 1959. 61 pp. Presentation of the design of a chamber-pressure and mixture-ratio control system to increase the safety and speed of testing and to investigate the general controllability of a regeneratively cooled hydrogen-fluorine rocket engine. The dynamics of the components of the system and the complete control loop are investigated. Time-history records of combustion-chamber pressure and mixture ratio illustrating control system's performance are also presented. Results show that the system is capable of starting a hydrogen-fluorine rocket engine, providing stable operation to within $\pm$ 2% of the present values of chamber pressure and mixture ratio, and limiting transient deviations in oxidant-fuel ratio sufficiently to avoid a stoichiometric mixture.

RESEARCH, RESEARCH FACILITIES

Wind Tunnels

A METHOD FOR MEASURING DAMPING-IN-PITCH OF MODELS IN SUPERSONIC FLOW. H. E. Maloy, Jr. US, BRL Rep. 1078, July, 1959. 37 pp. Development of a technique for measuring the damping-in-pitch of bodies of revolution in a supersonic wind tunnel over a Mach Number range of 1.75 to 4.5. An oscillograph is used to record the angular position of the model at any time, and the aerodynamic damping moments are computed from the measured rate of subsidence of the angle of attack. The installation of the model is specified, the need for a steady flow in the test section is stressed, and it is shown that the damping coefficient is a function of Mach Number and decreases with increasing Mach Number for the model tested; the damping coefficient is not very sensitive (a) to changes in Reynolds Number, or (b) whether the boundary layer of the model is laminar or turbulent.

ROTATING WING AIRCRAFT, HELICOPTERS

THE LOADING OF HELICOPTER ROTOR BLADES IN FORWARD FLIGHT. M. A. P. Willmer. Gt. Brit., RAE Rep. Naval 2, Apr., 1959. 57 pp. Description of a method for calculating the spanwise loading of helicopter rotor blades at various azimuth angles. The method is an extension of Glauert's lifting line theory. The problem is reduced to solving a series of simultaneous linear equations and the computations are performed by a digital computer. Theoretical results obtained by this method for tip speed ratios of 0.08, 0.15, and 0.29 show considerably better agreement with experimental results than those obtained by previous methods. It is also shown how the theory may be used to calculate the vertical forces transmitted by the blades to the rotor hub by a more accurate method than has hitherto been employed.

DYNAMICS OF A ROTOR CONTROLLED BY AERODYNAMIC SERVO FLAPS. Appendix I - CHANGE OF DISK TILT WITH FEATHERING (HOVERING OR VERTICAL FLIGHT). Appendix II - HOVERING STABILITY DERIVATIVES $\partial a_{1s}/\partial q$ AND $\partial a_{1s}/\partial \mu$. P. R. Payne. Aircraft Eng., Nov., 1959, pp. 330-339. Development of a theory describing the dynamic behavior, control angles to trim, and stability derivatives of an aerodynamic servocontrolled rotor. The analysis is restricted to constant chord rotor blades which are torsionally deformed by the servoflap to give changes in rotor pitch angle. Also, the aerodynamic center and elemental c.g. lines are assumed to coincide with the blade torsion axis. Since the stiff hinge assumption is used, the analysis is applicable to blades with offset or stiff flapping hinges, or to cantilever rotors, which can be simulated by a rigid blade with a stiff hinge. Comparison with some NACA test tower results shows that the theory developed gives an excellent agreement with available experimental results.

APPLICATION PRATIQUE DU CONTROLE D'UN ROTOR DE GIRAVION PAR VOLET DE BORD DE FUITE COMPORTANT LE SOUFFLAGE. René Dorand. Tech. & Sci. Aéronautiques, May-June, 1959, pp. 145-153. In French. Study of a method of helicopter rotor control by means of a jet flap at the trailing edge. The basic principles of the method are described, and the effect of blowing is evaluated for the cases of circulation and boundary-layer control. Includes presentation of characteristic coefficients of flight conditions; definition of the rotor fineness; experimental results for the case of maximum blowing; application of the results of a numerical calculation to the case of a helicopter rotor with mechanical transmission, covering analysis of theoretical results and application to practical cases; and evaluation of the decreased vibration rate, improved aerodynamic characteristics, and improved performance.

STRUCTURES

Bars & Rods

SHEAR BUCKLING OF BARS. G. Herrmann and A. E. Armenakas. Columbia U. Dept. Civ. Eng. & Eng. Mech. Inst. Flight Struc. TN 3 (AFOSR TN 59-1016), Oct., 1959. 11 pp. Analysis showing that a perfectly straight bar, subjected to a state of uniform shear stress will buckle, in a manner similar to a column under compression, if the shear stress exceeds a certain critical value. The buckling equations are obtained by the Newtonian approach, and also by the application of the principle of minimum potential energy. In order to provide additional insight into this buckling mechanism, a simple model is introduced and analyzed.

Elasticity & Plasticity

NOUVELLE METHODE DE MESURE DU COEFFICIENT DE POISSON. F. Girard. La Recherche Aéronautique, Sept.-Oct., 1959, pp. 19-24. In French. Development of a method for determining the Poisson coefficient, applicable to high temperatures. The method is based on the measured values of the fundamental frequencies in the case of longitudinal vibrations of two cylinders having the same length, one being very thin and the other with a diameter equal to its length. The mathematical approach to the problem is presented in detail; the experimental method is described and its accuracy is evaluated. The results include values of the Poisson coefficient for several pure metals and alloys, and the variations of the Young modulus and the Poisson coefficient as function of temperature are presented for pure aluminum, pure magnesium, and a titanium alloy ($TC3F_e$).

Plates

FINITE DEFLECTIONS OF THIN CAMBERED ELASTIC PLATES. R. L. Bisplinghoff. Franklin Inst. J., Oct., 1959, pp. 270-277. Development of a theory for computing the finite deflections of thin cambered elastic plates subjected to simultaneous bending and twisting moments. The relations between deflections and applied moments are nonlinear and are characterized by instabilities which arise as a result of chordwise deformation. Experiments are described which corroborate the theoretical trends.

MINIMUM WEIGHT ANALYSIS OF ORTHOTROPIC PLATES UNDER COMPRESSIVE LOADING. George Gerard. J. Aero/Space Sci., Jan., 1960, pp. 21-26, 64. Presentation of minimum weight analysis of various forms of stiffened-plate construction for use as compression covers of multicell wing box beams. Longitudinal, transverse, and waffle-grid stiffening systems for flat plates are studied by use of orthotropic plate theory and the assumption that the buckling modes occur simultaneously. After obtaining results for each stiffening configuration, the comparative structural efficiencies of the various types of plates are then considered in terms of common parameters.

ON THE STRESS PROBLEM OF ANISOTROPIC WEDGES. J. P. Benthem and J. v. d. Vooren. Netherlands, NLL TN S.537, Feb. 23, 1959. 31 pp. 11 refs. Analysis considering infinite anisotropic wedges with prescribed loads in their plane along the edges. The differential equation for Airy's stress function is given in terms of oblique coordinates. Solutions are derived, including the case of unloaded edges. The latter problem involves the case where the stresses within the wedge result in a concentrated load at the vertex. The given methods can be extended for other boundary conditions.

ON THE DIFFUSION OF A LOAD FROM AN EDGE-STIFFENER INTO A WEDGE-SHAPED PLATE. J. P. Benthem and J. v. d. Vooren. Netherlands, NLL TN S. 541, July 16, 1959. 47 pp. 12 refs. Development of a method to calculate the stress distribution in wedge-shaped plates with an edge stiffener. Applications are given for the wedge angles $\alpha = 135^{\circ}$ and $\alpha = 180^{\circ}$. The results of the latter case deviate only about 0.1% from the known exact values, the singular behavior at the vertex and the asymptotic behavior at infinity.

Wings

TRANSIENT TEMPERATURE DISTRIBUTIONS IN AN INSULATED MULTI-SPAR WING. Appendix I - EXACT SOLUTION FOR THE TEMPERATURE DISTRIBUTION IN THE INSULATION. Appendix II - EXACT SOLUTION FOR THE TEMPERATURE DISTRIBUTION IN THE WEB. E. C. Capey. Gt. Brit., RAE Rep. Struc.246, Apr., 1959. 29 pp. Application of an approximate method to derive the transient temperature distributions and thermal stresses in an idealized insulated multi-spar wing subjected to aerodynamic heating. Approximate formulas obtained by this method are compared with exact solutions for a number of special cases and found to be in good agreement.

THERMODYNAMICS

EIN DIAGRAMM FÜR THERMO-GASDYNAMISCHE VORGÄNGE. Otto Lutz. ZFW, Oct., 1959, pp. 281-286. In German. Presentation of a diagram for thermogasdynamic processes applicable to air and combustible gases provided that the dissociation can be neglected. Examples illustrating the applicability of the diagram include isentropic compression and expansion, straight and oblique shocks, and mixing processes. A comparison with examples calculated with constant values of specific heat shows considerable discrepancies between the results.

Combustion

THEORY OF PARTICLE COMBUSTION AT HIGH PRESSURES. D. B. Spalding. ARS J., Nov., 1959, pp. 828-835. 30 refs. Analysis in which the transient effects dominating the burning process at high pressures, neglected in conventional theories, are considered in an attempt to predict the burning rates of fuel particles whether or not the phase boundary has completely disappeared. The differential equations which express the conservation and transport of matter and of energy when all the diffusivities are equal are presented. The latter assumption permits reaction kinetic considerations to be eliminated. The appropriate boundary condition for a phase interface is also stated. Then the quasi-steady theory is reviewed. It is shown that this is not even a first-order approximation to the transient problem. The quasi-steady formula for the burning time of a fuel underestimates the burning time when the pressure is large, the transfer number becomes high, and the gas condition approaches the stoichiometric. A new theory is derived which, when the property variations are neglected, gives the time variations of flame radius, burning rate, and combustion efficiency.

THE FASTEST BURNING FLAME - THE PREMIXED HYDROGEN-FLUORINE FLAME. A. V. Grosse and A. D. Kirshenbaum. Temple U. Res. Inst. TN 8 (AFOSR TN 59-621), Feb. 2, 1959. 72 pp. 36 refs. Development of techniques for premixing pure hydrogen and fluorine gas. Burning velocities, both at 77° and 90°K. of various hydrogen-fluorine mixtures, with and without helium dilution, were determined. The hydrogen-fluorine flame is the fastest flame known and burning velocities up to 2,100 cm. per sec. at 77°K. were measured. Under the same conditions, the hydrogen-oxygen flame has a velocity of approximately 200 cm. per sec. or ten times smaller. The hydrogen-fluorine flame is also characterized by an unusually high flame pressure; a maximum of 60 mm. Hg has been determined.

HETEROGENEOUS COMBUSTION OF MULTICOMPONENT FUELS. Appendix - DETERMINATION OF DISTILLATION CURVES FOR BINARY FUEL MIXTURES. B. J. Wood, Henry Wise, and S. H. Inami. US, NASA TN D-206, Nov., 1959. 32 pp. 14 refs. Study of the combustion characteristics of a fuel drop containing liquid constituents of different physical and chemical properties. A photoelectric shadowgraph apparatus is used to measure directly the rate of change of cross-sectional area of a burning drop. The variation of burning-rate coefficient as a function of drop composition is determined for a group of binary fuel mixtures. In addition, the burning characteristics of drops of hydrocarbon fuels containing up to five constituents and of industrial fuel mixtures, such as kerosene and JP-4, are studied. Results indicate that during combustion the composition of a multicomponent fuel drop changes by a process of simple batch distillation; temperature and composition gradients within the burning drop appear to be modified by internal circulation of the fuel; and, for a given fuel mixture, the stability of the drop during the combustion process is found to be a function of the initial drop size, the nature and relative quantities of the components in the liquid phase, and the magnitude of the differences in their boiling points.

METAL COMBUSTION PROCESSES. Irvin Glassman. Princeton U. Dept. Aero. Eng. Lab. Rep. 473 (AFOSR TN 59-1093), Aug., 1959. 37 pp. 92 refs. Study of the burning characteristics of light metallic elements. The conclusions are based on fundamental physical considerations and not on experimental results. An analytical approach to calculate the burning rate of metals is suggested. This approach differs from the diffusion-droplet approach in that it includes radiation feedback and loss terms. Such terms can be important at the high temperatures of the diffusion film surrounding a burning metal.

Heat Transfer

A METHOD FOR THE RAPID NUMERICAL SOLUTION OF THE HEAT CONDUCTION EQUATION FOR COMPOSITE SLABS. J. W. Enig. US, NAVORD Rep. 6666, Aug. 20, 1959. 19 pp. Analysis showing that for certain simple geometries (single or double slab), it is possible to compute the outer surface and any interior point temperatures for a prescribed surface heat flux without computing other interior point temperatures. The partial differential equations are integrated in terms of an arbitrary outer surface temperature, the solution joined to the remaining boundary condition, and the resulting integral equation evaluated for the outer surface temperature or flux by a simple numerical scheme. The method performs an exact integration over the space dimension. Once the outer surface temperature is determined, the interior temperatures are computed by exact formulas.

O PERIODICHESKIKH RESHENIIAKH URAVNENIIA TEPLOPROVODNOSTI. P. V. Cherpakov. MVO SSSR VUZ Izv. Matemat., No. 2, 1959, pp. 247-251. In Russian. Derivation of periodic solutions for the equations of heat transfer in finite and infinite regions characterizing the propagation of heat waves. The boundary conditions are stated, and the solutions are presented for such cases as the temperature field in an inhomogeneous body or in moving media; heat transfer in a sphere; and the case of a three-dimensional region D, bounded by a surface s, assuming that the direction of the tangential plane and main curvature varies constantly.

VTOL & STOL

LES PRINCIPES EXPERIMENTAUX UTILISES DANS L'ETUDE ET LA MISE AU POINT D'UN AVION VTOL. G. Ernst. Tech. & Sci. Aéronautiques, May-June, 1959, pp. 159-164. 12 refs. In French. Survey of various experimental principles used in the study and the development of VTOL aircraft. The problems considered include the ground effect; landing impact; vertical flight; and transition, covering the take off and landing as a conventional aircraft, model testing, flight simulators, and test beds.

A METHOD OF DESIGN OF SHROUDED PROPELLERS. V. O. Hoehne and R. E. Monical. U. Wichita, Dept. Eng. Res. Rep. 213-8, Oct., 1959. 35 pp. ONR-supported development of a design method using information from several investigations, and application of the method to the design of several wind tunnel models. Methods are presented for determining annulus flow velocity, propeller thrust coefficient, propeller design, exit vane design, and shroud design. Results of tests on one of the models are compared with predicted data to establish the validity of the method. The comparison shows that the method predicted performance within the range of normal design accuracy.

A PRELIMINARY DESIGN TECHNIQUE FOR ANNULAR-JET GROUND-EFFECT MACHINES (GEM'S). H. R. Chaplin. US, Navy Dept., David Taylor Model Basin, AL Aero Rep. 966 (TED TMB AD-3242), Sept., 1959. 12 pp. Presentation of mathematical formulas and curves sufficient to describe a ground-cushion vehicle and its hovering performance. The approach consists of a mathematical model incorporating all of the significant descriptive dimensions of the vehicle. In addition, several efficiency factors have been introduced to account for effects to be encountered in operation. Additional supporting equations are provided to fully describe the physical conditions of the vehicle in hovering. The performance description method also allows comparisons to be made of different vehicle designs.

COMPARISON OF EXPERIMENTAL AND THEORETICAL DESIGN PARAMETERS OF A 6-INCH-DIAMETER ANNULAR JET MODEL WITH A JET ANGLE OF -45° HOVERING IN PROXIMITY TO THE GROUND; AND EXPERIMENTAL RESULTS FOR FORWARD FLIGHT AT ZERO ANGLE OF ATTACK. A. A. Tinajero. US, Navy Dept., David Taylor Model Basin, AL Aero Rep. 954 (TED TMB AD 3242), May, 1959. 58 pp. Presentation of static and dynamic test results of an annular jet model. The effects of ground proximity upon the aerodynamic characteristics are investigated. Lift, drag, and pitching-moment coefficients are determined. The "annular jet nozzle" was found to be highly effective as a lift producer. It is found that the lifting property that exists in the static configuration at low pressure ratios decays with increasing forward speed. At the higher pressure ratios, the loss is still very great at very low forward speeds, but there is some recovery as the speed is increased.

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Aeroelasticity

Steady State Response of a Simple System with a Hysteretic Spring. E. R. Rang. *USAF WADC TR 59-121*, July, 1959. 16 pp. 10 refs.

The Use of the WKBJ Method to Estimate Transient Effects on Structural Response. R. E. Kelly. *J. Aero/Space Sci.*, Dec., 1959, pp. 850, 851. Application of the WKBJ method to estimate the effect of a continuous variation in stiffness on the impulsive pitch response of a two-dimensional airfoil.

A Modification of Rayleigh's Principle for Calculating Beam Frequencies. F. M. Lewis. *ASME Trans., Ser. E - AM*, Sept., 1959, pp. 452–454. Presentation of a simplified method applicable to hinged end, cantilever, and free-free beams.

Flutter of an Untapered Wing Allowing for Thermal Effects. E. G. Broadbent. *Gt. Brit., ARC CP 442*, 1959. 13 pp. BIS, New York, $0.45.

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On the Natural Modes and Their Stability in Nonlinear Two-Degree-of-Freedom Systems. R. M. Rosenberg and C. P. Atkinson. (*ASME Annual Meeting, New York, Nov. 30–Dec. 5, 1958, Paper 58—A-57.*) *ASME Trans., Ser. E - AM*, Sept., 1959, pp. 377–385.

Anti-Vibration Mounting of Aircraft Power Plants. III—Design and Testing of Rubber Anti-Vibration Units. IV—Rig Test-Bed and Flight Testing of Power-Plant Anti-Vibration Mounting. J. F. Harriman. *Aircraft Eng.*, Sept.; Oct., 1959, pp. 262–265; 304–307. 23 refs.

Airplanes

Air Conditioning, Pressurization

Development of an Emergency Pressurization System for an Escape Capsule. A. E. Miller and E. H. Replogle. *USAF WADC TR 58-397* [*AD 216307*], May, 1959. 41 pp.

Cockpits, Canopies, Windshields

Relaxed Alertness in the Cockpit. Jerome Lederer. *SAE Natl. Aero. Meeting, New York, Mar. 31–Apr. 3, 1959, Preprint 51S.* 32 pp. Presentation of results of an opinion survey on the problem of retaining crew vigilance. The survey suggests that the design of cockpits should be considered on an integrated basis rather than piece by piece, with more attention given to practical use under varying conditions.

Control Systems, Automatic Pilots

Flight Investigation of a Centrally Located Rigid Force Control Stick Used with Electronic Control Systems in a Fighter Airplane. W. R. Russell and W. L. Alford. *U.S., NASA TN D-102*, Sept., 1959. 30 pp. Study of a force or rigid control stick of conventional size and location. The output signal of the force stick was proportional to the stick force rather than to the stick displacement. The main purpose of the program was to obtain pilot's opinions on this type of controller and to compare the control characteristics with those of a movable or displacement type control stick.

Flying Qualities Associated with Several Types of Command Flight Control Systems. S. A. Sjoberg. *7th Anglo-Am. Aero. Conf., New York, Oct. 5-7, 1959, Paper 59-134.* Members, $0.50; nonmembers, $1.00. 15 pp. Presentation of results of flight investigations on the flying qualities associated with several types of command flight control systems.

The Future of Automatic Control of Fixed Wing Aircraft. G. A. Whitfield. *7th Anglo-Am. Aero. Conf., New York, Oct. 5-7, 1959, Paper 59-142.* Members, $0.50; nonmembers, $1.00. 15 pp. Discussion of the advantages to be gained by treating auto-controls as an essential component of the aircraft and the possibility of designing such controls.

Description

Commercial Aircraft of the World. *The Aeroplane & Astronautics*, Oct. 16, 1959, p. 335. Design and performance characteristics of jet and turboprop aircraft.

The Intercontinental DC-8 Jetliner. *Douglas Serv.*, July-Aug., 1959. 60 pp. Presentation of design and systems characteristics of the aircraft, including noise suppressor and thrust brake, fuel, air conditioning, ice protection, electric power, hydraulic, and landing gear systems, control surfaces, communications and navigation systems, and safety equipment.

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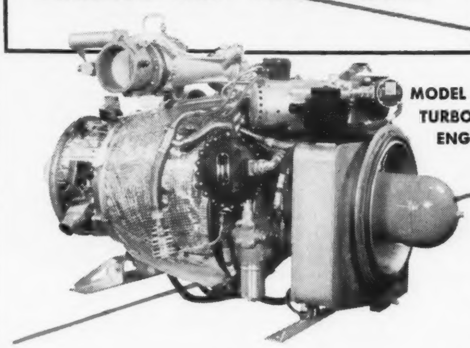

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Design Features of the DC-8 Jetliner. II—Structure. *Douglas Serv.*, Sept.-Oct., 1959. 24 pp.

CL-44D Seeks to Tap All-Cargo Market. R. I. Stanfield. *Av. Week*, Nov. 2, 1959, pp. 52, 53, 55, 59–74 (ff.). Design, performance, structural, and system characteristics of the swing-tail turboprop transport aircraft.

Power for the Long-Range Supersonic Airliner. R. R. Jamison. (*IAS Annual Summer Meeting, Los Angeles, June 16–19, 1959, Rep. 59–118.*) *Aircraft Eng.*, Sept., 1959, pp. 266–271.

Entwicklung des V-Leitwerks. II. *Der Flieger*, Oct., 1959, pp. 350–352. In German. Survey of the procedures and test methods employed in the development of the He-162 and He-280 aircraft with V-type tail units.

Design Philosophy for High Acceleration and Temperature. B. O. Heath. *7th Anglo-Am. Aero. Conf., New York, Oct. 5-7, 1959, Paper 59-132.* Members, $0.50; nonmembers, $1.00. 23 pp. Study of the practice of specifying flight profiles for the investigation of fatigue, for endurance tests, and for operational performance. Design processes are described, covering the relationship of temperature and time introduced by heating and acceleration.

The Technical Development of the DHC-4 Caribou Utility STOL Aircraft. R. D. Hiscocks. *7th Anglo-Am. Aero. Conf., New York, Oct. 5-7, 1959, Paper 59-140.* Members, $0.50; nonmembers, $1.00. 23 pp. Survey of the design and performance characteristics of a twin-engine aircraft.

Landing, Landing Loads

Measurements and Power Spectra of Runway Roughness of an Airport (Airport 1). A. H. Hall and D. C. Smith. *NATO AGARD Res. Memo. 1*, Mar., 1959. 28 pp.

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The Work of the Blind Landing Experimental Unit. W. J. Charnley. *7th Anglo-Am. Aero. Conf., New York, Oct. 5-7, 1959, Paper 59-131.* Members, $0.50; nonmembers, $1.00. 27 pp. Description of a system developed for the RAF which uses a conventional autopilot coupler in the initial approach phase, then switches to a receiver that detects the difference in signals from two magnetic leader cables spaced symmetrically about the extended runway centerline, and derives an exponential flare path from a radio altimeter.

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Blind Take-Off and Landing Considerations for Present and Future Aircraft. N. C. Harnois and G. H. Stocker. *7th Anglo-Am. Aero. Conf., New York, Oct. 5-7, 1959, Paper 59-145.* Members, $0.50; nonmembers, $1.00. 11 pp. Discussion of the requirements of take-off and landing systems, and description of six possible systems.

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Tire-to-Surface Friction-Coefficient Measurements with a C-123B Airplane on Various Runway Surfaces. R. H. Sawyer and J. J. Kolnick. *U.S., NASA Rep. 20*, June, 1959. 56 pp. 11 refs.

Study and Preliminary Design of a High Temperature Aircraft Wheel, Brake, and Tire Assembly. G. T. Stout. *USAF WADC TR 59-210 [AD 216630]*, May, 1959. 79 pp. 67 refs.

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Some Aspects of Future Air Transport Possibilities. George Gardner. (*CAI Spec. Anniversary Meeting, Montreal, Feb. 23, 1959.*) *Can. Aero. J.*, Oct., 1959, pp. 324–339. Survey of aspects of growth in, and future opportunities for, the development of air transport, covering in particular: high-speed flight problems, VTOL and STOL aircraft, the weather problem, and all-weather approach and landing.

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Comfort Evaluation of the C-118 Pilot Seat (Aerotherm); One of a Series of Studies Pertaining to the Design Evaluation of Pilot and Crew Station Equipment. R. F. Slechta, J. Forrest, W. K. Carter, and E. A. Wade. *USAF WADC TR 58-312 [AD 212559]*, Mar., 1959. 16 pp.

Aviation & Space Medicine

Disorientation in Flight: An Evaluation of the Etiological Factors. R. N. Kraus. (*Aero Med. Assoc. 30th Annual Meeting, Los Angeles, Apr. 29, 1959.*) *Aerospace Med.*, Sept., 1959, pp. 664–673. 13 refs. Historical survey of the development of instrument flight and review of the physiological mechanism involved in maintaining aerial orientation.

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Physiologic Response to Subgravity—Mechanics of Nourishment and Deglutition of Solids and Liquids. J. E. Ward, W. R. Hawkins, and H. D. Stallings. *USAF SAM Rep. 59-2*, Jan., 1959. 4 pp.

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Direct Current Potentials of the Central Nervous System. L. R. Pinneo. *USAF RADC TN 59-137 [AD 214692]*, June, 1959. 55 pp. 185 refs. Description of the electrical polarization of the normal brain of the mammal indicating two types of steady potential: the resting potential present in the absence of stimuli, and a second potential due to incoming sensory volleys. An assessment of their theoretical value is included.

The Influence of Venous Infusion of Gaseous Carbon Dioxide on Oxygen Saturation of Arterial Blood and Cardiac Output in the Anesthetized Dog. F. G. Hall and John Salzano. *USAF WADC TR 59-378*, July, 1959. 5 pp.

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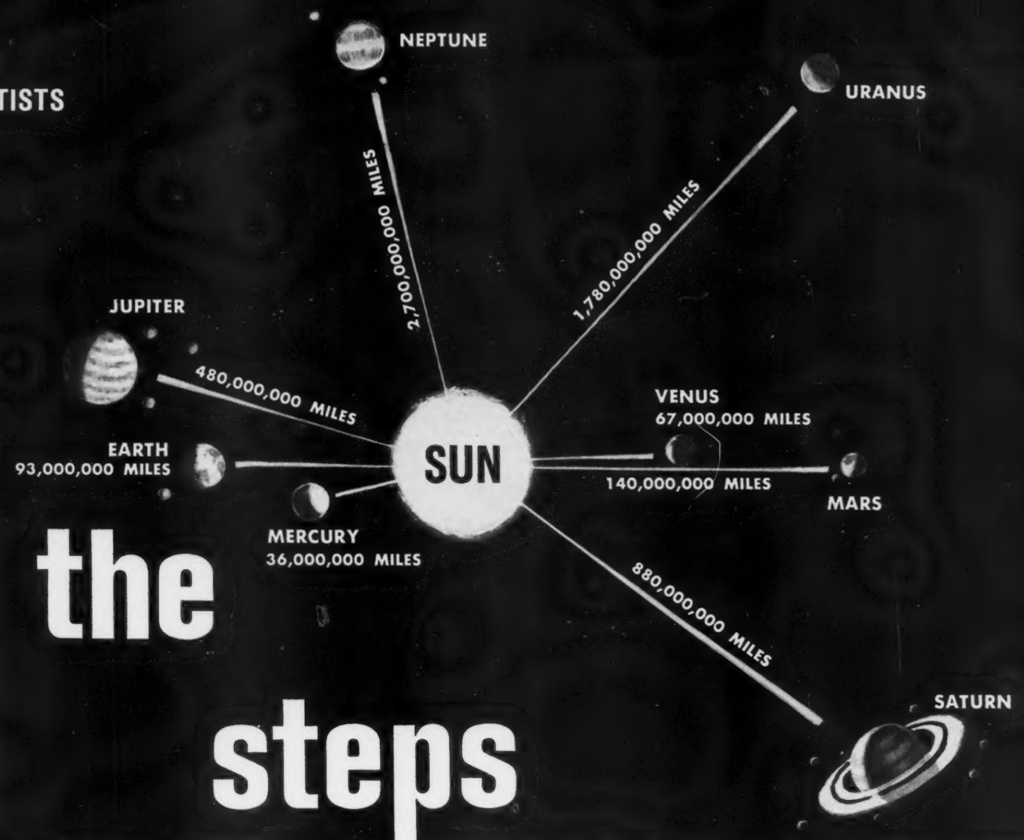

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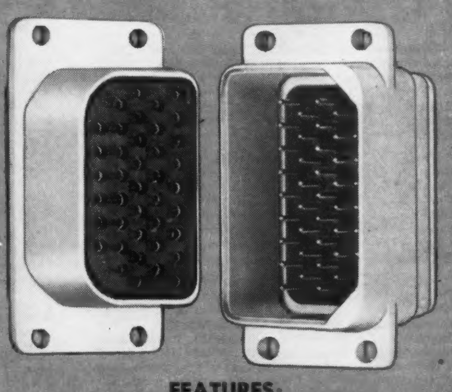

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sight and scatter propagation, including a status report on the turbulent theories of tropospheric irregularities. The complementary problems of signal statistics and electromagnetic-propagation calculations are summarized and compared with available data.

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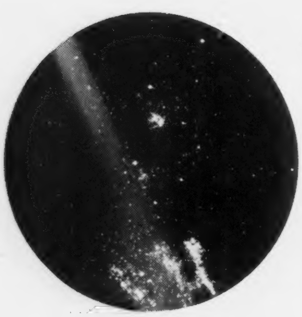

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zero rows is a permutation matrix. From this, an inspection method is described for determining whether a non-negative matrix is nilpotent. Application is made to graph theory.

Numerical Analysis

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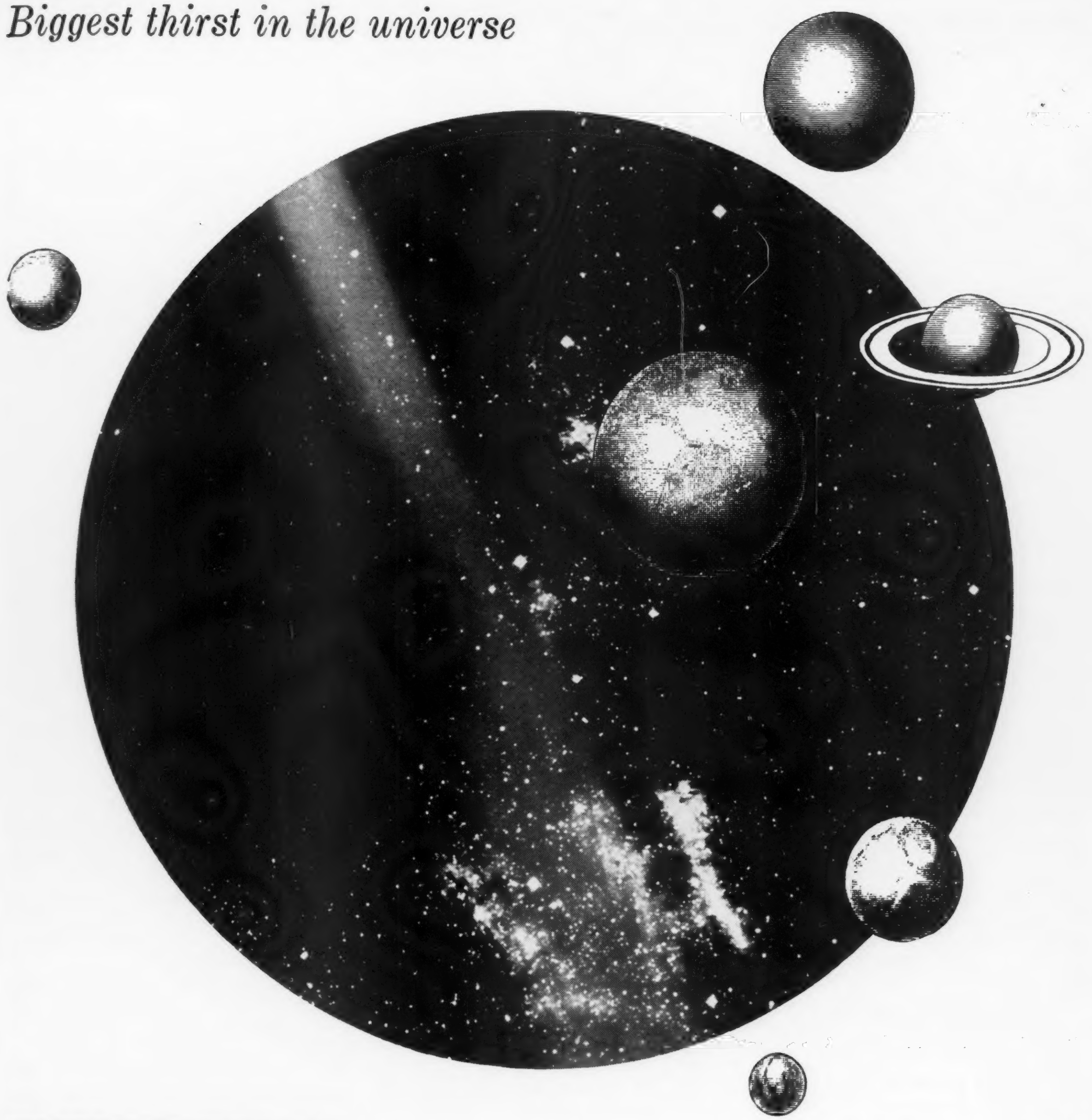

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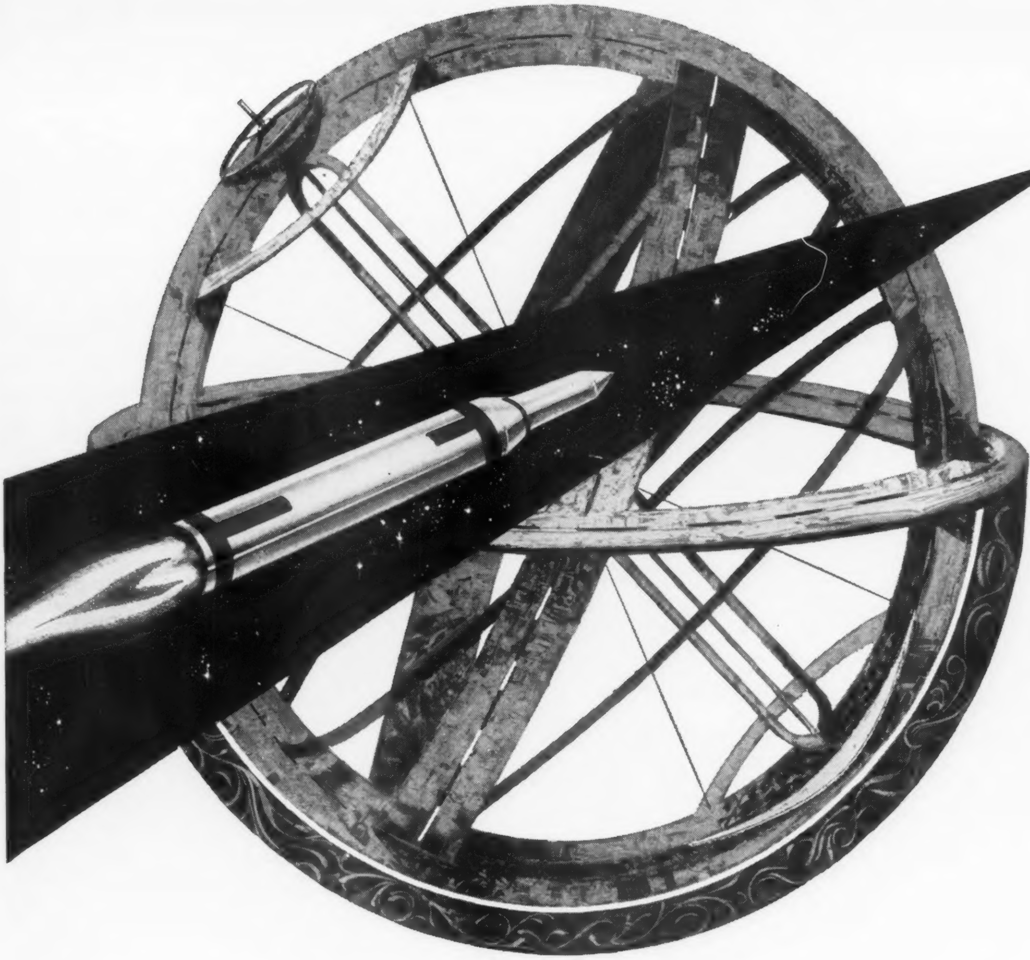

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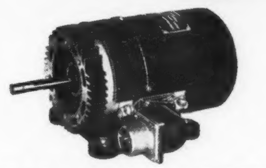
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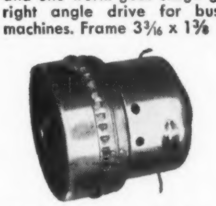
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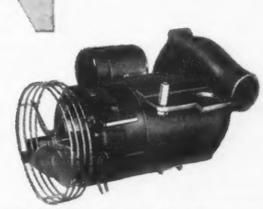
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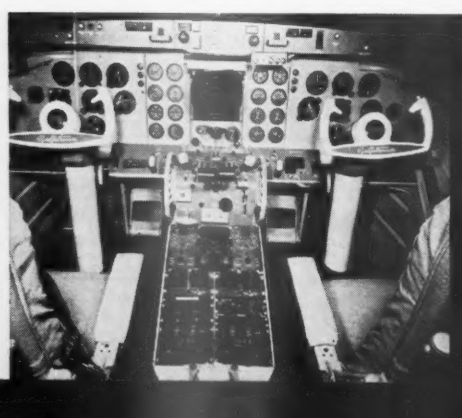

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(*Continued on page 112*)

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IAS Section News *(Continued from page 26)*

distinction of being cumulative and built upon itself rather than a collection of distinct and separable works. Books, journals, and literature are the heart of science, with the trend toward journals in conveying the technical word. Today journals carry more than one half of the literature printed.

At this meeting a new Section Chairman John A. Carran, was elected to replace Marcy Fannon, recently transferred.

F. A. ROSENTHAL, *Secretary*

New Mexico Section

W. Randolph Lovelace, II Views Manned Space Flight

"**Interrelation of the Life and Physical Sciences in Manned Space Flight**" was presented by **Dr. W. Randolph Lovelace, II** (F), Director of the Lovelace Foundation for Medical Education and Research, before the October 20 dinner meeting at Kirtland AFB.

Dr. Lovelace opened his discussion with a few observations on his recent visit to Russia and his impressions of their space program. He felt that the Russians probably had as many, or more, failures of vehicles than we have had but that they were not very well publicized. As for testing equipment, Dr. Lovelace stated that the Russians have a three-rail track, 3 miles in length, for creating high g loads on various test objects and a 30-ft. centrifuge facility. He also noted that they have very large and well-populated animal farms, and little difficulty in obtaining all the monkeys desired.

The professional people, engineers, and scientists, are chosen for advanced schooling strictly in accordance with results of I.Q. tests. The Russians have selected their man in space candidates who, like ours, are military pilots. Dr. Lovelace felt that the Russians have an immediate capability for placing a man in space but that re-entry problems are causing postponement.

Dr. Lovelace summarized the methods used in selecting our candidates for flight in space and described the thorough physical examinations which these men had to undergo. Divided into groups of six, the men were routed through the Lovelace Clinic on an examination program which required a total of 7 days and part of 3 nights to complete.

Next, Dr. Lovelace described some of the characteristics of the space capsule, stating that it must be extremely well sealed and not subject to air leakage above 500 cu. cm./min. It is expected that approximately 8*g* will be encountered by the occupant, thus necessitating a contour couch to prevent injury. He stated that it is extremely difficult to ascertain a human being's response to the weightlessness to which he will be subjected while being propelled into space. The first flights of the space capsule are expected to be about 120 miles above the earth and will be programed for three times around the earth with landing down-range from Cape Canaveral. Total time of flight will be about $4^1/_2$ hours. If a landing is not accomplished after three round trips, 16 more trips will be required in order to land at the desired down-range point. It is hoped and expected that voice communication will be in existence during the flight, along with 16 channels of telemetering transmitting mostly biological data on the occupant.

The capsule will have sufficient air purification equipment for 48 hours of flight. Although there are seven individuals selected for Project Mercury, no one has yet been chosen to make the first flight. For this flight a principal with an alternate standing by is planned in case there is a delay in launch.

Dr. Lovelace concluded his talk with a showing of slides of advanced laboratory equipment and test methods utilized in giving the future space men their physicals.

LT. COL. L. T. BOATWRIGHT, JR., USAF
Secretary

Taking part in St. Louis TV series for 1959 were, *left to right*, Richard Fitzgerald, Hal Spragg, Bryan Marvin, Jim Dutson, Gordon LeBert, Robert Rippe, and Bernard Lee.

Niagara Frontier Section

Business Aircraft on the Uprise

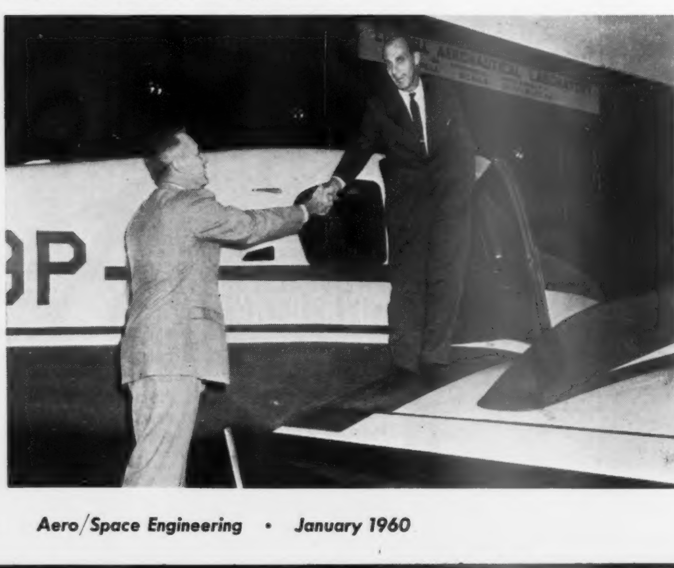
"**The Use and Design of Light Business Aircraft**" was discussed by **Howard Piper,** Vice-President for R&D for the Piper Aircraft Corp., before 50 persons at the October 14 meeting.

Mr. Piper showed how the convenience and economies of flying business aircraft have created a rapidly expanding market which has resulted in a 600 per cent increase in usage since 1946. He discussed how the field has a wide latitude with many possible variations of products. Mr. Piper emphasized the importance of low aircraft cost and how it can be achieved by effective production design and production techniques.

Officers for the coming year are Edward Y. Sing, Chairman; Jonn M. Schuler, Vice-Chairman; John M. Cord, Secretary; Murray Kamrass, Treasurer.

JOHN M. CORD, *Secretary*

Howard Piper, standing on wing, is greeted on his arrival in Buffalo by Walter Brenhaus, Niagara Frontier Section Meeting Chairman.



St. Louis Section

Television Series on Aerospace Flight

The St. Louis Section, which for the past 3 years has brought various aspects of aerospace flight to the attention of St. Louisans via television, is now planning a new TV series to be produced this spring.

The 1959 two-program series, entitled "Advancing the Frontiers of Space with St. Louis Industry," was concerned with the problems of manned space flight. It was written and produced by Gordon LeBert (A) of McDonnell Aircraft Corp.

Participating in the programs were Bryan Marvin, Public Relations Dept., Monsanto Chemical Co., who discussed chemical problems; Robert S. Rippe, Manager, Applications Engineering, Solid Propellant and Military Explosives, Energy Div., Olin Mathieson Chemical Corp., whose subject was propulsion problems; and Bernard Lee, Advanced Servo Engineer, Electronic and Avionic Div., Emerson Electric Manufacturing Co., who presented the problems involved in guidance. Other participants were Hal Spragg, Associate Director, Biological Research Lab., Universal Match Corp., whose subject was physiological problems; and Richard Fitzgerald, Application Engineer, Customer Service Div., McDonnell Aircraft Corp., who discussed manned space capsule problems. Host for both programs was Jim Dutson of KMOX-TV staff.

FREDERICK H. ROEVER
Member Advisory Board

San Antonio Section

Mercury Space Capsule

"**Human Parameters in Outer Space**" were discussed at the September 22 meeting by **Col. Paul A. Campbell, USAF** (AF), Chief of the Space Medicine Division of the School of Aviation Medicine at Brooks AFB.

Referring to the Mercury Space Capsule as a "six-by-six world," Colonel Campbell pointed out that the first astronauts will be facing an entirely new sensation in their complete isolation from the earth. He said that some of the stresses contributing to this new sensation are increased reaction time for the simplest coordinated movement; visual disturbances, particularly in the light-accommodation area, caused by the extreme intensity of all reflected light in the total darkness of space; hypoxia tendencies; and the perpetual weightless state of matter in space orbit.

Colonel Campbell stated that stresses of these types increase geometrically instead of arithmetically, and the total result will have a terrific impact on human psychosocial factors. An approach to the solution of these human problems has been in a very careful and objective selection of men with the proper psychosocial factor balance that will enhance the success of their missions; giving the select men as much of a "conditioning" for space travel as is possible under simulated space conditions; and providing some type of computer control to compensate for the reaction time delay.

The presentation was illustrated with color slides and a color movie of an F-100 type aircraft flying a series of parabolic curves to produce weightlessness and demonstrate the behavior of liquids in the weightless state.

Following this presentation, Section Officers for the coming year were installed: John C. Henson, Chairman; Robert R. Perry, 1st Vice-Chairman; John V. Moffitt, 2nd Vice-Chairman; John S. Curry; and Bob A. Roberts, Treasurer.

JOHN S. CURRY, *Secretary*

San Diego Section

The Spirit of St. Louis Panel Discussion

The design and construction of the Spirit of St. Louis airplane which Charles A. Lindbergh flew in the first solo transatlantic flight in 1927 was discussed before the October 3 dinner meeting.

The panel was made up of a moderator, William P. Brotherton, Public Relations Manager, Ryan Aeronautical Co., and four other men. Donald A. Hall (AF), Supervisor, Helicopter Engrg. Branch, NAS North Island, was Chief Engineer for the plane, while John van der Linde, Factory Manager, Ryan Aeronautical Co., was Flight Line Mechanic, and Fred H. Rohr, Chairman of the Board, Rohr Aircraft Co., was proprietor of Standard Sheet Metal Works, subcontractor on the Spirit of St. Louis. Charles W. Frick (AF), Chief Technical Engineer at Convair, represented the modern aircraft engineer's point of view.

Slides and motion pictures illustrated the discussion which demonstrated the enthusiasm that existed in the early days of the industry.

FRANK W. PARRY
Corresponding Secretary

Seattle Section

707—One Year

The story behind the introduction of the Boeing 707 into airline service was presented by a five-man panel made up of representatives of the Boeing Transport Division who were intimately associated with the 707 from its inception. The discussion was held before more than 250 members and their guests at a dinner meeting on September 30.

M. L. Pennell (AF), Chief Engineer of the Division, led the discussion and introduced the other members of the panel. **R. L. Rouzie,** Assistant Chief Engineer—Production, reviewed the overall status of the 707 production effort and pointed to the general success of the engineering philosophy behind the 707 and to the enviable record achieved by Boeing in delivering airplanes on or ahead of schedule. Mr. Rouzie also gave an interesting account of his impressions during the just completed proving flight of the 707 Intercontinental from Seattle to Tokyo and return.

W. H. Cook (M), Chief of Technical Staff, discussed the philosophy behind the major design decisions that were made at the time the 707 project was initiated. He pointed out that these were made on the basis of the engineering experience accumulated on the B-47 and B-52 airplanes and at a time when there was virtually no competitive product against which to measure the 707 design. With this background it is interesting to compare the 707 with competitive designs that followed. His conclusion was that, taken as a whole, the correctness of the basic design decisions had been proved and that the 707 compares very favorably with other aircraft of the same class.

The following speaker, **R. L. Loesch,** Chief Experimental Pilot, gave an interesting discussion of the problems encountered in the certification of a completely new type of aircraft at a time when the rules governing its certification for civil use were in the process of being written. With essentially four different basic models of the 707 to be certified, this situation finally resulted in the certification of these airplanes under three different sets of rules, with a much larger engineering and flight-test effort than would be required under more normal conditions.

Considerable support by Boeing to the program of indoctrination and qualification of airline pilots was also necessitated because of the introduction of a basically new type of airplane to scheduled airline service. The checkout time for airline pilots in some cases ran as high as 35 hours instead of the contemplated 15 hours. The most significant reason cited was the urgency felt by the airlines to press newly delivered airplanes into regular service rather than divert them for training duty.

R. M. Morgan, Service Manager, underlined the fine service record achieved by the 707 during the initial year of service by giving some impressive statistics. With approximately 60 airplanes delivered to airlines at the present time, a total of 66,000 hours of flight time has been logged and 2 $^3/_4$ billion passenger-miles flown. During this time the airlines have achieved a 7.5 hour/day average utilization of the airplane for all operations, with the high time being 12.1 hours/day by some operators over a period of several months. An unprecedented average load factor of 92 per cent for all operations has been achieved, indicating the tremendous passenger appeal of the 707 and its ability to help generate new business for the airlines. Mr. Morgan pointed out that transition from piston-type airplanes to the jets has been accomplished with a minimum of delays and quite possibly with greater efficiency than for any other re-equipment program in airline history. The overhaul and maintenance record of the Pratt & Whitney J-57 engines has been an important factor in the achievement of the overall record of safety and reliability attained by the 707.

Mr. Morgan also made the interesting observation that the troubles that had shown up in the operation of the airplane were largely confined to the more conventional systems on the airplane such as the hydraulic, air conditioning, and water injection system. Such troubles as had shown up were being eliminated as rapidly as possible by the fixes in the field and minor design changes as necessary.

The individual discussions by the panel members were followed by a question-and-answer period which reflected the wide range of interest in the 707 program and served to highlight some of the speakers' remarks.

Another program item for the meeting was the introduction of Section Officers for the coming year: V. M. Ganzer, Chairman; Yusaf Yoler, Vice-Chairman; J. K. Wimpress, Secretary; and W. S. Huntington, Treasurer.

L. B. GRATZER, *Retiring Secretary*

Texas Section

Howard F. Marx, Development Planner, Looks at Operations Research

"Operations Research, Management, and the Future," was the subject of a discussion by **Howard F. Marx** (AF), Manager of Development Planning for Temco Aircraft Corp., before the October 14 Specialists Meeting.

Using military situations as examples, Mr. Marx illustrated the basic principles of Operations Research problem solution and the application of the mathematical Theory of Games. Other examples showed the techniques of Waiting Line Theory and Weighted Probabilities. Some specialized management problems were discussed, including inventory and production scheduling. In the area of future applications, the simulation of an entire business operating in its competitive market environment offers the most challenging and potentially the most worth-while opportunities for the solution of non-scientific problems by scientific techniques.

CLYDE MURTAUGH, *Secretary*

Tullahoma Section

AEDC Plans and Policy Chief

Donald W. Male (AF), Acting Chief of Plans and Policy for USAF Hq., Arnold Engineering Development Center, briefly reviewed the available literature on the properties of the upper atmosphere at the October 13 meeting. Mr. Male's talk was followed by a discussion concerning the recent Explorer satellite data on the Van Allen radiation belt.

1959–1960 officers elected are Chairman, Michael Pindzola; Vice-Chairman, Donald W. Male; Secretary, William L. Chew, Jr.; Treasurer, Lee F. Webster; and Advisers, Julius Lukasiewicz, John M. Wild, Rudy W. Hensel, and Donald R. Eastman, Jr.

MILTON W. DAVIS, *Retiring Secretary*

Tulsa Section

Developing the Grumman Gulfstream

"Engineering and Flight Development of the Gulfstream Executive Transport" was the topic of a discussion by **Alden L. Rogers** (AF), Project Aerodynamicist for Grumman Aircraft Engineering Corp., before a dinner meeting held on October 13.

Mr. Rogers presented a color film entitled *Grumman Gulfstream* which depicted the development of this executive transport. Approximately 3 years ago the Grumman became aware of the need for an airplane for the corporate executive. Performance of the airplane had become extremely important, and the airplane's use as a management tool was now well known. After a survey of numerous companies, Grumman undertook this design to satisfy the need for an executive transport. The airplane was designed to meet CAR o4B and the special turbine airplane requirements. The performance of the airplane has been designed around the small town airports.

The airplane will take off at sea level with a gross weight of 33,600 lbs. in 2,800 ft. The range of the airplane is 2,200 miles, plus adequate reserve, at a speed of 350 m.p.h. The cabin is pressurized to sea level up to 15,500 ft. At an altitude of 30,000 ft. the cabin altitude is only 8,000 ft. Adequate maintenance accessibility was built into the airplane permitting a reduction in maintenance time and cost. The airplane first flew in August, 1958, and certificated in May, 1959. Present production is four airplanes per month. After the film, Mr. Rogers answered many questions from the audience concerning design features of the airplane.

P. C. JOHNSON, *Recording Secretary*

Washington Section

Joint Meeting Introduces Doak 16; September Meeting on Meteorology

A flight demonstration of Army aircraft, highlighted by the Doak 16 VTOL, opened the joint IAS/AHS meeting on October 13. **Major Gen. Clifton Von Kann,** Director of Army Aviation, Office of the Deputy Chief of Staff for Military Operations, was principal speaker at the dinner following the demonstration.

The "16," introduced at Davison Army Air Field, Fort Belvoir, as a main feature of the meeting showed great capabilities from an initial STOL take-off, through an impressively fast low-level fly-by and various other demonstrations, to the final VTOL take-off and transition followed by a transition back to VTOL configuration and landing. No artificial stability or damping systems were required.

Honorary Chairman for the meeting, Ralph Alex, AHS President, spoke briefly at the dinner on the significance of the helicopter now and in the future. He noted the economy of the very large turbine-powered helicopter, some of which the Russians are putting into service, and pointed out their speed and lack of noise as compared to present service types.

General Von Kann directed his talk to operational aspects of the mobility offered the Army by aviation. He indicated the requirements, problems involved, and distinct advantages gained in battlefield mobility in the utilization of airplanes and helicopters in Army aviation.

The General said strategic mobility, including logistics, is of major importance, particularly for limited warfare where deployment of forces to, and maintenance in, any area of the world are required. The problems of deploying helicopters make it necessary for vehicles to have inherent capability for self-development strategically. For helicopters this could involve a concept of fixed staging bases within their ferry range or in-flight refueling techniques. Tactics will develop around the need to maintain integrity of forces and their mobility.

With an ICBM stalemate, limited war is of primary concern for Army field operations. The economic limits to be considered dictate a series of plateaus from present availability to future requirements. Airplanes and helicopters now in advanced development stages represent the next plateau beyond present capabilities, while outgrowths of present research vehicles will follow as the next level. Design of these vehicles should be based on consideration of factors presented by General Von Kann.

▶ The September 15th meeting presented **"Weather Forecasting Utilizing Rockets, Satellites, and Other Advanced Techniques"** by **Jack C. Thompson,** Executive Assistant for Technical Planning, U.S. Weather Bureau.

Mr. Thompson discussed some of the problems facing the weather man and the potentially attractive solutions to these problems offered by advanced techniques. He presented new methods of measurement and forcasting, including correlation between their results and other measurements, problems involved in their use, and the anticipated gains to be made in weather prediction.

HAROLD ANDREWS, *Secretary*

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Letters to the Editor

(Continued from page 5)

Chap. II, Appendix "A," by Floyd B. Garrett and G. M. Ault, and Chap. VII by G. M. Ault.

(2) *Analysis of Some Failure Data,* by D. J. Davis, Journal of American Statisticial Association, Vol. 47, June, 1952, pp. 133–150.

and texts on the application of statistical techniques in industry. I believe that these and other references adequately support the statements on statistics in my letter to the Editor of AERO/SPACE ENGINEERING, May, 1959.

Lewis A. Rodert, FIAS
Research Assistant
California Div.
Lockheed Aircraft Corp.

Attention Members!

All Members of the Institute are invited to submit material concerning their activities for publication in the news columns of Aero/Space Engineering.

REVIEWS OF *Books*

. . . in the field of aeronautical engineering and space technology

AIRPORTS

Airport Buildings and Aprons; A Reference Document of Principles and Guidance Material for Use by Those Concerned With the Planning of Airport Buildings and Aprons. 2nd Ed. Montreal, IATA, August, 1959. 179 pp., diagrs., tables. $2.00.

This document combines the basic information contained in *Airport Buildings and Aprons* (July, 1956) with that of the later *Apron Requirements for Turbine-Powered Aircraft*, as well as new material produced as a result of recent airline operating experience.

In carrying out this present revision, IATA's aim has been to provide a handbook of consolidated, up-to-date airline opinion. Emphasis has been directed toward the requirements of turbine-powered aircraft. Helicopters at airports receive attention, and a brief glossary of terms in English, French, and Spanish has been provided.

CRYOGENICS

Progress in Cryogenics, Volume 1. K. Mendelssohn, Editor. New York, Academic Press, Inc., 1959. 259 pp., illus., diagrs., tables. $11.

Contents: Superconducting Circuits, D. R. Young. Thermoelectric Cooling, D. A. Wright. Evacuated Powder Insulation for Low Temperatures, M. M. Fulk. Distillation at Low Temperatures, B. R. Brown. The Measurement of Mechanical Properties of Metals at Low Temperatures, H. M. Rosenberg. Frozen Free Radicals, G. L. Minkoff Low-Temperature Calorimetry, R. W. Hill. The Determination of Specific Heats by the Temperature-Wave Method, N. V. Zaviritsky. Ultrasonic Attenuation in Metals at Low Temperatures, R. W. Morse.

DICTIONARIES

Dictionary of Aeronautical Engineering. J. L. Nayler. New York, Philosophical Library, Inc., 1959. 318 pp., diagrs. $10.

The four or five thousand terms appearing in this illustrated dictionary reflect the large and complex nomenclature employed by aeronautical engineers. Consequently, a great many chemical and electronic terms are concisely defined, as well as those most commonly met in the subjects of aerodynamics, aircraft design, propulsion, materials, mathematics, and flight. A large selection has also been taken of terms created by postwar developments in jet propulsion, high speed flight, helicopter engineering, VTOL aircraft, rockets, missiles, and artificial satellites. Abbreviations and acronyms are included.

ELECTRICAL EQUIPMENT

Aircraft Electrical Engineering. Edited by G. G. Wakefield. (A series of Textbooks Published Under the Authority of the Royal Aeronautical Society.) London, New York, The Macmillan Co., 1959. 349 pp., illus., diagrs., tables. $10.

The information given in this book is based on a series of lectures given at the Imperial College of Science and Technology, London, during September, 1954, by contributors who are active members of the aircraft industry. Special attention has been given to the presentation of environmental characteristics and the problems of high-altitude brush wear. The cooling of electrical machinery is also covered, especially for high-speed aircraft.

Contents: Introductory Survey, S. F. Follett, M. Hancock, and D. F. Welch. Environmental Conditions and Functional Requirements, M. Hancock. The Nature and Physical Cause of High-Altitude Brush Wear, R. F. Sims. Vibration Problems, M. Hancock and R. F. Sims. Cooling of Aircraft Electrical Machines, C. S. Hudson. Direct Current Machines, B. Adkins and W. Philipp. Alternating Current Machines, W. Philipp. Switchgear, A. Grieve. Aircraft Batteries and Their Behaviour on Constant-Potential Charge, G. A. Earwicker. Electrical Power Systems, J. H. Rea. Electrical Installations Engineering, H. Zeffert. System Operation and Protection, K. J. Payne. Future Trends, S. F. Follett. Index.

FLUID MECHANICS

Proceedings of the Sixth Midwestern Conference on Fluid Mechanics, University of Texas, September 9–11, 1959. Austin, Tex., The University of Texas, 1959. 465 pp., illus., diagrs., tables. $12.50.

Contents: Recent Progress in Rarefield Gas Dynamics Research, S. F. Schaaf. An Extended Reynolds Analogy, W. Squire. On Laminar Heat Transfer to the Stagnation Line Region of a Highly Yawed Cylinder, J. T. C. Liu. Determination of Convective Heat Transfer to Non-Isothermal Surfaces Including the Effect of Pressure Gradient, J. P. Hartnett, E. R. G. Eckert, and R. Birkebak. Steady State Fusible Body Shapes in a Heated Supersonic Stream and Hypersonic Stream, S. T. Chu and J. D. Lee. Secondary Flow in Straight Open Channels, J. W. Delleur and D. S. McManus. Variation of the Wind Profile with Meteorological Parameters, J. A. Singer and G. S. Raynor. Spherical Explosions in Sea Water, S. A. Berger and M. Holt. Spectral Relations in Homogeneous Turbulence of an Incompressible Fluid, F. N. Edmonds, Jr. The Blade Frequency Velocity Field Near an Operating Marine Propeller Due to Loading and Thickness Effects, J. P. Breslin and S. Tsakonas. On Turbulent Plane-Couette Flow, J. M. Robertson. Virtual Mass and Slender-Body Theory for Bodies in Waves, P. Kaplan and P. N. Hu. Flow Characteristics of a Circular Submerged Jet Impinging Normally on a Smooth Boundary, M. Poreh and J. E. Cermak. Tangent Flows, L. M. Milne-Thomson. Laplace Transformation Solution of Simultaneous Linear Flow in Two Regions by a Fixed Boundary, W. T. Guy, Jr., L. B. Lesem, and G. W. Crawford. Hypersonic Flow Around Bodies of Revolution Which Are Generated by Conic Sections, M. Vinokur. An Approximate Theory for the Pressure Distribution and Wave Drag of Bodies of Revolution at Mach Number One, J. D. Cole and W. W. Royce. Particulate Dynamics Research at Sandia Laboratory, J. R. Banister. Film Characteristics and Dimensions in Annular Two-Phase Flow, H. N. McManus, Jr. Temperature Determinations of Methane-Air Combustion Products by Velocity-of-Sound Measurements, V. D. Agosta and H. D. Baker. An Electro-Mechanical Transducer for Measuring Dynamic Pressures in Fluids, D. A. Gilbrech. The Organized Boundary Layer, F. N. M. Brown. On the Measurement of Local Skin Friction by Means of a Surface Probe in the Case of Low Speed Turbulent Flow over a Porous Flat Plate with Mass Injection, B. M. Leadon and E. R. Bartle. Scale Effects in Turbulent Shock Wave Boundary Layer Interactions, A. G. Hammitt and S. Hight. The Gas Lubricated Finite Slider Bearing, C. C. Mow and E. Saibel. The Hydrodynamic Lubrication of Section Thrust Bearings, L. N. Tao. Theoretical and Experimental Study of Heat Transfer by Cellular Convection in the Presence of Impressed Magnetic Fields, Y. Nakagawa. Canonical Forms, Beltrami Flows and Certain Exact Solutions in Magneto-Gasdynamics, M. Z. v. Krzywoblocki and J. T. Martin. The Wave Motions of Small Amplitude in Radiation-Electro-Magneto-Gasdynamics, S. I. Pai and A. I. Speth. Further Results on the Flow of a Conducting Fluid Past a Magnetized Sphere, G. S. S. Ludford and J. D. Murray.

Fluid Dynamics. D. E. Rutherford. Edinburgh, Oliver & Boyd; New York, Interscience Publishers, Inc., 1959. 226 pp., illus., diagrs., tables. 10s. 6d. $1.95.

Dr. Rutherford has based his book upon courses of lectures given to Honors students in the University of St. Andrews, where he is presently Reader in Applied Mathematics. In his account of the fundamental principles, he takes care to emphasize the distinction between real fluids and the mathematical models employed in making calculations; thus the treatment is not confined to the classical theory of nonviscous incompressible fluids, although essential topics such as that of the Joukowski transformation are given prominence. In the chapter on compressible flow, the reader is introduced to linearized theory, shock waves, and the Prandtl-Meyer expansion. The chapter on viscosity discusses the Navier-Stokes equations and their simpler exact solutions, and the concepts of Prandtl's boundary layer.

FUELS & LUBRICANTS

The Performance of Lubricating Oils. H. H. Zuidema. 2nd Ed. (American Chemical Society, Monograph Series No. 143.) New York, Reinhold Publishing Corp., 1959. 205 pp., illus., diagrs., tables. $7.00.

The purpose of this monograph is to assemble under a single cover the salient features of the many papers on various phases of lubricating oil technology that have been published since the appearance of the first edition in 1951. Selected references have been added to the bibliographies in each chapter, and corresponding revisions and additions have been made in the text. Table 1, for example, has been greatly expanded in accordance with newly published data to facilitate the conversion of various viscosity units. Among the new subjects in this edition are multigrade motor oils, fretting wear, and paper chromatography.

The author is a member of the Products Application Department, Shell Oil Co.

Boron High-Energy Fuels. Report of the Committee on Science and Astronautics, U. S. House of Representatives. October 13, 1959. (86th Congress, 1st Session, House Report No. 1191.) Wash., USGPO, 1959. 14 pp.

Boron High Energy Fuels. Hearing Before the Committee on Science and Astronautics, U.S. House of Representatives. August 26, 27, and September 1, 1959. (86th Congress, 1st Session.) Wash., USGPO, 1959. 137 pp.

LAWS & REGULATIONS

Controls for Outer Space; and the Antarctic Analogy. Philip C. Jessup and Howard J. Taubenfeld. (Columbia University Studies in International Organization, Number 1.) New York, Columbia University Press, 1959. 379 pp. $6.00.

All parts of this book are related to the ultimate problems of control of outer space, but the detailed exposition of that subject is reserved for Part 3. Of rather special relevance is the situation in the Antarctic; this is dealt with in Part 2. As an introduction to the foregoing regions, the authors recall in Part 1 the most relevant portions of the history of international organization; condominiums; trusteeships; the cases of Danzig, the Saar, Trieste, etc.; and the numerous instances of functional organizations which deal with communications, health, commodities, transport, welfare, and many other aspects of human activities.

Phillip C. Jessup is Hamilton Fish Professor of International Law at Columbia, while Howard J. Taubenfield is Professor of Law at the Golden Gate College, San Francisco, and a practicing attorney.

MATHEMATICS

Probability and Related Topics in Physical Sciences. Mark Kac. (Lectures in Applied Mathematics, Vol. 1.) London, New York, Interscience Publishers, Inc., 1959. 266 pp., diagrs., tables. $5.60.

This book is an expanded version of lectures delivered at the Summer Seminar in Applied Mathematics held in Boulder, Colo., in 1957. The book is intended to furnish an introduction to probability theory to mature audiences with little or no prior knowledge of the subject. The present volume is the first of four arising from the Seminar.

Contents: (1) Nature of Probabilistic Reasoning. (2) Some Tools and Techniques of Probability Theory. (3) Probability in Some Problems of Classical Statistical Mechanics. (4) Integration in Function Spaces and Some Applications. Appendix I: The Boltzmann Equation, G. E. Uhlenbeck. Appendix II: Quantum Mechanics, A. R. Hibbs. Appendix III: Smoothing and "Unsmoothing," Balth. van der Pol. Appendix IV: The Finite Difference Analogy of the Periodic Wave Equation and the Potential Equation, Balth. van der Pol. Bibliography. Index.

Nomography. A. S. Levens. 2nd Ed. New York, John Wiley & Sons, Inc., 1959. 296 pp., diagrs., tables. $8.50.

As in the first edition, which appeared in 1948, the present edition emphasizes the "geometric method" in the development of the basic theory which is used for the design of alignment charts that may involve three or more variables. The treatment of the "determinant method" has been expanded considerably over that of the first edition.

Another feature of this edition is the introduction of the Duality Principle and its application to the transformation of families of experimental data curves from the Cartesian coordinate system (concurrency charts) to the parallel

IAS REPORTS

Twenty-Seventh Annual Meeting, New York, January 26–29, 1959*

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coordinate system (alignment charts). The appendix contains 58 nomograms which are useful examples of applications in such fields as engineering, science, business, statistics, heat transfer, satellite launching, and radioactivity.

Alexander S. Levens is Professor of Mechanical Engineering, University of California, Berkeley.

NOISE

Industrial Noise Manual. Detroit, American Industrial Hygiene Association, 1958. 184 pp., diagrs., illus., tables. $7.50.

This manual contains information on the physical characteristics of noise, its measurement, its effect on exposed persons, and its control. The primary purpose is to supply the industrial hygienist with the information necessary to appraise and reduce most noise exposures except those of sufficient complexity to warrant the attention of acoustical specialists. Many of the chapters may also prove useful and interesting to medical, safety, and engineering personnel.

PHYSICS

Exploding Wires; Based on Conference on the Exploding Wire Phenomenon, April, 1959, Conducted by Geophysics Research Directorate, AFCRC, USAF, with the Cooperation of Lowell Technological Institute Research Foundation. Edited by William G. Chace and Howard K. Moore. London, Chapman & Hall, Ltd.; New York, Plenum Press, Inc., 1959. 373 pp., illus., diagrs., tables. $9.50.

Contents: A Brief Survey of Exploding Wire Research, W. G. Chace.

Theoretical and Experimental. The Current Pause in an Exploding Wire, R. J. Reithel, J. H. Blackburn, G. E. Seay, and S. Skolnick. Submicrosecond Wire Exploding Studies at Electro-Optical Systems, Inc., F. H. Webb, N. Chase, M. Ernstene, and A. Tollestrup. Conductivity During "Dwell Time" of a Wire Explosion, W. G. Chace, R. L. Morgan, and K. R. Saari. The Electrical Behavior of Fine Wires Exploded by a Coaxial Cable Discharge System, T. J. Tucker and F. W. Neilson. Large Exploding Wires—Correlation to Small Wires and Pause-Time Versus Length Dependency, E. C. Cnare and F. W. Neilson. Use of the "Action Integral" in Exploding Wire Studies, G. W. Anderson and F. W. Neilson. Exploding Wire Phenomena at Reduced Pressures, T. Korneff, J. L. Bohn, and F. H. Nadig. The NRL—AFSWP Exploded Wire Research Program, V. E. Scherrer. The Pinch Effect in the Exploding Wire Phenomenon, J. Katzenstein. Radiometric Temperature Measurements of Exploding Wires, E. B. Mayfield. Radial Distribution of Current and Its Effect in an Exploding Wire, R. C. Maninger. The Cinemicroscopic Observation of Exploding Wires, D. Zernow and G. Woffinden. Studies of Exploding Wire Phenomenon by Use of Kerr Cell Schlieren Photography, W. Müller.

Shock Waves. Flow Fields Produced by Exploded Wires, F. D. Bennett. Theoretical Analysis of the Hydrodynamic Flow in Exploding Wire Phenomena, C. A. Rouse. On the Propagation of Cylindrical Shock Waves, A. Sakurai. Exploding Wires, Calculation of Heating, E. David.

Applications and Technique. Bonding Experiments with Exploding Foils, D. Schiff. Image Formation of the Rapid Vaporization of Metal Filaments in Vacuo by the Sensitization and Autoradiographic Methods, L. E. Preuss. Applications of the Exploding Wire Technique in Photochemistry, R. A. Marcus. A Reliable Three-Channel Delayed Wire Exploder Unit, E. E. Walbrecht. High Power Pulse Steepening by Means of Exploding Wires, G. S. Janes and H. E. Koritz. High Voltage, Quick-Acting Fuse to Protect Capacitor Banks, H. B. McFarlane. High-Speed Framing Camera for Photographing Exploding Wire Phenomena, F. H. Nadig, J. L. Bohn, and T. Korneff. Exploding Wire Plasma Accelerator, W. L. Starr.

Properties of Matter. F. C. Champion and N. Davy. 3rd Ed. New York, Philosophical Library, 1959. 334 pp. $10.

The important change in this new edition is the gradual orientation of the subject from a largely phenomenological treatment to atomic interpretations. Among the topics discussed are the acceleration due to gravity, the Newtonian constant of gravitation, elasticity, capillarity, and seismic waves, osmotic pressure, diffusion, viscosity, the compressibility of solids and liquids, and errors in measurement.

The authors are both Readers in Physics: Mr. Champion at King's College, University of London; Mr. Davy at the University of Nottingham.

Technical Report, 1957-9, Part 1, Laboratory of Molecular Structure and Spectra, Dept. of Physics, The University of Chicago. Robert S. Mulliken, Principal Investigator. Chicago, The University, 1959. 251 pp., illus., diagrs., tables.

Part 1 of the *Technical Report 1957-9* consists largely of the reprinted papers on molecular spectroscopy and related matters. It also includes a group of theoretical papers on hyperconjugation, and three papers on free-electron molecular orbital theory.

RESEARCH

Basic Research in the Navy; A Report to the Secretary of the Navy by the Naval Research Advisory Committee, June 1, 1959. Cambridge, Mass., Arthur D. Little, Inc., Vol. 1, 69 pp., Vol. 2, 102 pp., diagrs., tables, folding charts.

Upon recommendation of the Naval Research Advisory Committee, the Office of Naval Research initiated a contract with Arthur D. Little, Inc., on February 1, 1958, to perform a study to determine a basis for decision as to the proper level of support of basic research by the Navy Department.

Volume 1 is a brief monograph setting forth the principal findings of this study. *Volume 2* is a series of memoranda covering studies undertaken during the assignment, which led up to the principal findings. These are submitted in five appendixes: A, Method of Approach; B, Mathematical Model; C, Manpower Studies; D, Chronology of Naval Technical Developments; E, References and Source Material.

Bulletin and Annual Progress Report, 1959, Institute of Aerophysics, University of Toronto. Toronto, October, 1959. 166 pp., illus., diagrs.

In addition to information concerning the teaching staff, graduates, UTIA publications and seminars, and the requirements for a degree in aeronautical/astronautical engineering, this progress report contains information on the Institute's active research programs. These include the mechanics of rarefied gases, plasmadynamics, nonstationary gasdynamics, supersonic flows, aerodynamic noise, aerodynamics of VTOL, STOL, and ground effect vehicles, dynamics and aerodynamics of flight, structures, and miscellaneous studies such as the theory of wings in slipstreams and propulsion systems for space travel.

SPACE MEDICINE

Bioastronautics; Advances in Research. Randolph AFB, Texas, USAF School of Aviation Medicine, Air University. March 1959. 181 pp., illus., diagrs., tables.

Contents: Definitions and Subdivisions of Space (Bioastronautical Aspect), H. Strughold. Bio-Paks—Instrumentation and Biomedical Research. Primates in Space. Center of Gravity and Moments of Inertia Measurements for Seat Plus a Rhesus Monkey, H. G. Clamann. Summary of Immunochemical Analyses on Sera from Humans Exposed in a Simulated Altitude Chamber, W. G. Glenn. Survival of Terrestrial Micro-Organisms Under Simulated Martian Conditions, J. D. Fulton. Photosynthetic Gas Exchangers and Recyclers Used in Closed Ecological System Studies, W. A. Kratz. Man in Space. Physiologic Instrumentation of Man During Flight, C. H. Kratochvil. Carbon Monoxide Phenomena in Green Plants Systems, S. S. Wilks, R. M. Adams, J. A. Green, and E. G. Shaw.

SPACE TRAVEL

The Moon Car. Hermann Oberth. Translated from the German by Willy Ley. (*Das Mondauto*, Düsseldorf, 1959.) New York, Harper & Brothers, 1959. 98 pp., illus., diagrs. $2.95.

Since the lack of an atmosphere on the moon would make it impossible to use either helicopters or conventional aircraft for lunar exploration, a number of proposals for surface vehicles have been put forth during the last several years. Professor Oberth believes that most of these new vehicles are entirely too conventional for operation under lunar conditions, particularly when it is necessary to cross deep chasms in the moon's surface. *The Moon Car* therefore contains his own ideas and suggestions for the design and testing of a vehicle that would overcome such expected problems as fuel, terrain, extremes of temperature, and low gravity.

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368 pp., 98 illus., 1960—$12.50

QUANTITATIVE MOLECULAR SPECTROSCOPY AND GAS EMISSIVITIES

By S. S. Penner, Calif. Inst. of Tech.

Treats basic problems in quantitative molecular spectroscopy and gas emissivities, utilizing the classical results of radiation theory. Problems are representative of the types encountered in development of modern propulsion devices.

587 pp., 212 illus., 1959—$15.00

PROJECT SHERWOOD:

The U. S. Program in Controlled Fusion

By Amasa S. Bishop, U.S.A.E.C.

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216 pp., 50 illus., 1958—$6.50

ADDISON-WESLEY PUBLISHING COMPANY, INC.

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Back in 1956 this General Electric organization outgrew its quarters in Schenectady, N. Y. and moved to Philadelphia. Since then its research and development staff has increased 5-fold. A new move is fast becoming imperative and will be met by the $14,000,000 Space Research Center now under construction on a 132 acres site near Valley Forge Park. This construction will feature unique facilities, to be utilized in a long-term program, to expand the activities in the realm of space research and the development of space vehicles and systems—areas in which MSVD has already contributed so many notable advances:

- the FIRST re-entry at ICBM range with both heatsink and ablation methods
- the FIRST recovery of payload from space
- the FIRST movies of earth from space
- the FIRST flight demonstration of effective space vehicle stabilization control and navigation (control systems of interplanetary capacity)
- the FIRST measurements in space of earth's magnetic field and infrared radiation
- the FIRST meteorological information from space
- the FIRST organic plastic ablation material for nose cone re-entry protection capable of withstanding temperatures from 5,000 to 13,000°F

Currently a broad diversity of programs are under way at MSVD, offering assignments of exceptional interest to engineers and scientists qualified to work with a research-oriented organization. Your inquiries are invited regarding the following areas: SYSTEMS ENGINEERING • AERODYNAMICS • THERMODYNAMICS • GUIDANCE & CONTROL • INSTRUMENTATION & COMMUNICATION • PLASMA PHYSICS • GAS DYNAMICS • AERO-MEDICAL DESIGN ENGINEERING • ANTENNA & MICROWAVE DESIGN • SPACE MECHANICS • STRUCTURAL DESIGN • ENERGY CONVERSION • HUMAN FACTORS • ADVANCED POWER SYSTEMS • RELIABILITY ENGINEERING • PRODUCIBILITY ENGINEERING • ARMING AND FUZING SYSTEMS • APPLIED MATHEMATICS & COMPUTER PROGRAMMING

Write in confidence to: Mr. Thomas H. Sebring, Div. 2MA.

Missile & Space Vehicle Department

GENERAL ELECTRIC

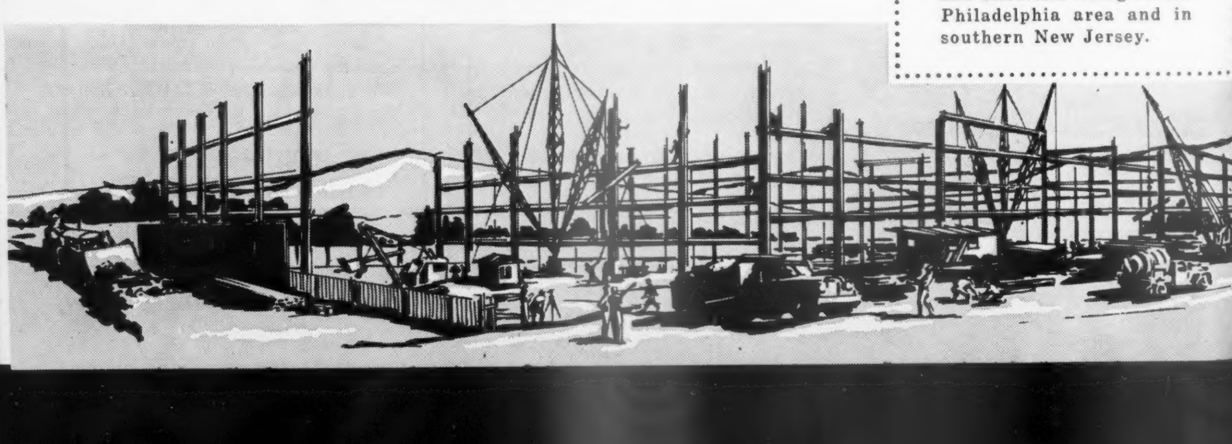
3198 Chestnut St., Philadelphia 4, Pa.

DIVERSITY OF ADVANCED PROGRAMS NOW UNDER WAY AT MSVD INCLUDE:

- Follow-on contracts for 2nd generation nose cones
- NERV (Nuclear Emulsion Recovery Vehicles) for NASA to study the lower Van Allen radiation belts at altitudes from 200 to 1800 miles
- STEER—a communications satellite to provide global military radio communications.
- Study programs in the area of accessory space power for a variety of missions, including chemical, nuclear and solar energy sources, electrolytic fuel cells and thermoelectric and thermionic converters
- Studies for three of the nation's space agencies to develop more accurate "space maps" than have hitherto existed to guide rockets and manned flights to the moon and planets

A well qualified scientist or engineer is likely to find advanced work going on at MSVD on almost any field of space research of special interest to him.

A campus-like setting is planned for the new Space Research Center which General Electric's Missile and Space Vehicle Department is building close to historic Valley Forge Park. Situated at the junction of the Schuylkill Expressway and Pennsylvania Turnpike, the Center will be easily reached by engineers and scientists living in the Philadelphia area and in southern New Jersey.



RESEARCH OPPORTUNITIES
In
SPACE SCIENCES

The Space Technology Operations of Aeronutronic has immediate need for engineers and scientists who are interested in working in the stimulating and highly diversified field of space sciences. This West Coast division of Ford Motor Company has the newest facilities and most advanced equipment for carrying out highly technical work—challenging creative work that is exceptionally rewarding to qualified men.

Positions are at Aeronutronic's new $22 million Research Center, being completed at Newport Beach, Southern California. Here, overlooking famous Newport Harbor and the Pacific Ocean, relaxed California living can be enjoyed free of big-city congestion, yet most of the important cultural and educational centers are just a short drive away.

AREAS OF INTEREST

VEHICLE TECHNOLOGY

- Aerodynamic design and testing
- Rocket Nozzle and re-entry materials
- High temperature chemical kinetics
- Combustion thermodynamics
- High temperature structural plastics and ceramics
- Advanced structures

SYSTEMS DEVELOPMENT

- Aerothermodynamics
- Re-entry programs
- High temperature heat transfer
- Penetration systems
- Hyper environmental test systems

ELECTRONICS AND ASTRO SCIENCES

- Astro navigation
- Space communications and communication satellites
- Instrumentation, telemetering and data reduction
- Space environmental physics
- Advanced techniques and system studies

Qualified applicants are invited to send resumes and inquiries to Mr. G. B. Eaton, Aeronutronic, Dept. 13, Box 451, Newport Beach, California.

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Personnel Opportunities

This section is for the use of individual members of the Institute seeking new connections and eligible organizations offering employment to specialists in the aero/space industry. Any member or eligible organization may have requirements listed without charge by writing to the Secretary of the Institute.

Wanted

Senior Aerodynamics Engineers—Curtiss-Wright has immediate openings for qualified personnel for projects involving Hypersonic Test Vehicles, Supersonic Target Missiles, and VTOL aircraft. Experience in conducting theoretical and experimental studies in aerodynamics including preliminary design, test planning, data analysis, and proposal and report writing. Minimum 5 years of related experience with M.S. degree preferred. Must be able to assume project responsibility. **Aerothermodynamicist**—Immediate openings for qualified personnel for research program with Hypersonic Test Vehicle and to perform aerodynamic heating investigations on new missiles. Minimum 2 years of related experience with B.S. degree. Send detailed résumé and salary requirements to Personnel Dept., Curtiss-Wright Corp., Santa Barbara Div., 6767 Hollister Ave., Goleta, Calif.

Professor—To teach courses in aerospace engineering and to design and supervise construction of teaching and research laboratory facilities and do part-time research. Advanced degree and industrial experience desirable. Salary and rank dependent upon qualifications. Address inquiries with personal data and photograph to Head of Dept. of Aeronautical Engineering, Alabama Polytechnic Institute, Auburn, Ala.

Engineers—To manage the development of U.S. Army's aviation program. The U.S. Army's aviation program requires continuing development of new helicopter light aircraft and related ground support equipment. The aircraft and helicopters are in speed, weight, and range categories which will permit the development engineer to make a major contribution toward their successful development. Form 57 applications are desired from engineers who have had past practical experience in design and development. Although most of the openings are at either GS-12 ($8,810) or GS-11 ($7,510) levels, there are several openings for engineers at the GS-13 level ($10,130). Engineers who have worked in one or more of the following areas are needed: **Air Frames Branch**—Structural design, basic loads and weight and balance, stress analysis, landing gear design, aerodynamics, controls, flutter and vibration, flight stations and instrumentation. **Propulsion Systems Branch**—Reciprocating engines, turbine engines, engine control, propellers, rotors, transmissions, and propeller engine vibration. **Aircraft Systems Branch**—Hydraulics, pneumatics, electrical, electrical systems auxiliary equipment, heat and vent, environmental, and armament. **Evaluation & Analysis Branch**—Performance analysis, mathematical analysis, analytical statistician, metallurgist, materials engineer, and reliability analyst. **Ground Support Equipment Branch**—Has openings for electrical and mechanical engineers with experience in the design of aviation ground support equipment. Other vacancies in the Development Division are **Assistant Chief Development Engineer** (GS-13), **Aircraft Systems Branch Chief** (GS-13), **Evaluation & Analysis Branch Chief** (GS-13), **Administrative Engineering Assistant, and Program Planner.** Under Civil Service Regulations, a job offer cannot be made until a Form 57 has been rated by the local Civil Service Commission. Form 57's can be obtained from a local Civil Service office or by writing to Larry C. Franzoi. The complete Form 57 should be forwarded to Larry C. Franzoi, Civilian Personnel Office, Headquarters, Transportation Supply and Maintenance Command, 12th & Spruce, St. Louis 66, Mo.

Aerodynamicist—B.S.Aero.; at least 5 years' experience with good background in theoretical and experimental missile aerodynamics. A working knowledge of stability and missile dynamics highly desirable. Should be capable of assuming responsibility of monitoring test programs. Will work for young expanding company recognized as a leader in its field with fine opportunity for advancement. Prewitt Aircraft Co., Clifton Heights, Pa.

Aeronautical Engineer—To teach in the military and civilian programs of the Aviation Safety Division of the University of Southern California. Opportunity for graduate study and research. B.S. in Aeronautical Engineering is required, with advanced degree preferred. Experience required: minimum of 3 years' work in preliminary design, aerodynamics, structures, or power, plants; pilot experience mandatory, missile experience desirable. Salary is $9,000 and up, depending on qualifications and experience. Annual vacation of one month. Apply in writing with brief résumé to Engineering Section, Aviation Safety Div., University of Southern California, Los Angeles 7, Calif.

Teaching Positions—Aerospace Science, Aeromechanical and Mechanical Engineering. Faculty appointments at ranks and salaries commensurate with experience and education are available for teaching in the areas of propulsion, systems analysis, instrumentation, gas dynamics, combustion, plasticity, aeroelasticity, structural dynamics, vibrations, lubrication, and celestial mechanics. Excellent graduate research facilities are available with exceptional opportunities for research. New doctoral program. Applicants for professional appointments are required to have a doctorate or the equivalent in research and teaching experience. Applicants for instructorship are required to have a Master's degree and be willing to under-take a program leading to a doctorate at either this or a neighboring institution. Applications from scientists in fields other than mechanical or aeronautical engineering are welcome. Applications should be sent to Prof. John F. Lee, Head, Dept. of Mechanical Engineering, North Carolina State College, Raleigh, N.C.

Teaching—Expansion of the Aeronautical Engineering Department at the University of Illinois has created new positions at senior professorial levels in the fields of aerodynamics, astronautics, propulsion, aeroelasticity, and structures. These positions provide opportunity for undergraduate and graduate teaching and research. Advanced education and experience in appropriate fields of specialization are necessary. Positions at the instructor and assistant levels are also available for qualified individuals desiring to continue graduate studies leading to the doctorate in aeronautical engineering. Write to Prof. H.

The number preceding the notice represents the Box Number of the Institute of the Aeronautical Sciences, Inc., 2 East 64th Street, New York 21, N.Y., to which inquiries should be addressed.

PERSONNEL OPPORTUNITIES

SUPERVISORY

Aerodynamicists

Preferably with advanced degrees and at least 6 years experience in:

- **Aerodynamic Analysis**
- **Stability, Vehicle Dynamics and Trajectory Mechanics**
- **Preliminary Design**
- **Theoretical, Experimental or Applied Research**

. . . to work in these specialties on problems related to flight of lifting and non-lifting vehicles at extremely high speeds and altitudes.

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Research & Advanced Development

201 Lowell St., Wilmington, Mass.

S. Stillwell, Head, Aeronautical Engineering Dept., University of Illinois, Urbana, Ill.

Engineering Test Pilot & Flight Test Engineer—FAA has immediate openings for one qualified Engineering Test Pilot and one Flight Test Engineer to conduct commercial certification projects out of New York Regional Office (vacancies also exist in other regions and Washington). Pilot must meet requirements of Civil Service Commission Announcement 169B; previous engineering test piloting experience required, plus aeronautical engineering background. Flight Test Engineer must be Aeronautical Engineer with at least 3 years' experience in aerodynamic performance or flight testing of airframes. Salary range GS-11 to GS-13 ($7,030 to $10,130). Applicants file Federal Employment standard form 57 with Personnel Officer, FAA, Federal Building, New York International Airport, Jamaica, N.Y., or call W. F. Norton, OLympia 9-7000, Ext. 265.

933. Faculty Positions—in Departments of Aeronautical, Mechanical, Electrical Engineering and Applied Mechanics. Subject fields of aerodynamics, thermodynamics, nuclear power, heat transfer, and engineering materials. Desire individuals with doctral degrees to develop strong offerings in undergraduate and graduate courses, plus initiation of research of own choosing. Salaries open, consulting opportunities available.

Available

935. Aeronautical Engineer—Graduate Aeronautical Engineer, over 16 years' experience aircraft and missiles, 12 patents granted and pending, very broad interests, seeks challenging position working on new ideas in frontiers of science. Not interested in drafting or routine paper work.

934. Project Engineer—B.S.Ae.E., MIAS. Age 34. Project Engineer, with extensive experience in R&D of airborne ordnance devices, test vehicles, instrumentation, electronic packaging, recovery systems, and complete missile systems. Thoroughly familiar and well experienced in project management and direction of all phases of R&D from initial proposal through design, development, and production of complete systems. Ten-year proved record of accomplishment. Seeking permanent, active position in medium-sized plant. Complete résumé furnished on request with all inquiries held as confidential.

932. Aerodynamics Group Leader—Age 31, B.M.E. and Master's in A.E. Total of 9½ years' mechanical design experience with last 4 years in development of internal flow devices. Presently employed in responsible position—turbomachinery design. Desires to move into challenging development project. Will consider relocation. Complete résumé on request.

931. Engineer—Sales, Executive—Graduate registered mechanical; 42 years of age. Ten years with large aircraft manufacturer; 3 years office Secretary of Defense R&D; 4 years diplomatic service; 4 years architect-engineer firm. Formerly officer Marine Corps aviation. Top-level industrial and Governmental contacts. Highest positions attained Asst. Vice-President, Engineering, Sales. Résumé on request.

930. Field Service and/or Application Engineer—Good background in electromechanical, hydromechanical controls and components; turbomachinery. Fair general electronic background. Excellent top-level references and contacts, Southern California airframe and missile industry. Over 10 years with present employer as supervisory field service engineer. Can organize and manage small field service department. Current remuneration $10,000 plus. Prefers West Coast location for headquarters, but no objection to extensive travel.

929. Project Engineer—B.S.Ae.E.; 10½ years' experience in analysis and design of aircraft. Has carried varying degrees of structural responsibility during the development of seven military airplanes, with experience in all aspects of airframe design. Presently VTOL preliminary design project engineer. Duties include supervision and participation in aircraft and gas-turbine performance calculations, aircraft systems analysis flight-test and wind-tunnel data evaluation, preparation of technical proposals, brochures and reports, and making presentations. Seeking a creative position with a progressive company.

928. Engineering Executive—Chief Engineer, Manager of Engineering. Graduate electronic engineer, advanced studies in electronics and management. Current position, manager of engineering, manager of research and advanced developments with medium-size firm making aircraft and missile instruments. Many years of experience and proved record of accomplishment in engineering, research, management, and administration in the fields of military and missile electronics, atomic energy applications and weapons systems, servomechanisms, instrumentation and controls. Seeking active, expanding situation where background and capabilities can be most effectively translated into profit and growth.

✦ ✦ ✦

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Reviews

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and T. A. Kirchgessner. *U.S., NASA TN D-133*, Oct., 1959. 29 pp.

A Closed-Form Solution for Laminar Free Convection on a Vertical Plate with Prescribed, Nonuniform, Wall Heat Flux. R. P. Bobco. *J. Aero/Space Sci.*, Dec., 1959, pp. 846, 847.

VTOL & STOL

Research Studies on a Ducted Fan Equipped with Turning Vanes. A. W. Gilmore and W. E. Grahame. (*IAS 27th Annual Meeting, New York, Jan. 26–29, 1959, Rep. 59-59.*) *AHS J.*, Oct., 1959, pp. 11–21.

On Theories of the Duct Shape for a Ducted Propeller. L. Meyerhoff and A. B. Finkelstein. *Polytech. Inst. Bklyn., Dept. Aero. Eng. & Appl. Mech., PIBAL Rep. 484*, Aug., 1958. 79 pp. 19 refs. Review of analytical methods for calculating the shape of a duct enclosing an operating propeller. Limitations are discussed.

Engines for V.T.O.L. Aircraft. H. Pearson. *7th Anglo-Am. Aero. Conf., New York, Oct. 5–7, 1959, Paper 59-130.* Members, $0.50; nonmembers, $1.00. 30 pp. Survey of the development of flatriser-type VTOL aircraft, with particular emphasis on safety, tactical, economic, and technical aspects.

A STOL Aircraft with Slipstream Boost. G. Bruner. *The Aeroplane & Astronautics*, Oct. 9, 1959, pp. 310–313. Description of the Bréguet experimental aircraft for STOL operation, featuring several trailing edge flaps and large propellers which result in the downward deflection of slipstream and a considerable increase in lift.

Water-Based Aircraft

The Hydrodynamic Characteristics of a Submerged Lifting Surface Having a Shape Suitable for Hydro-Ski Application. V. L. Vaughan, Jr. *U.S., NASA TN D-51*, Oct., 1959. 39 pp.

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